IMAGE DATA PROCESSING PERIPHERALS FOR COMPUTER SYSTEMS

Return to
Steve Levine

COLOR FILM RECORDER

Model D48

OPERATION and PROGRAMMING

MANUAL

888-1900

DICOMED

DICOMED Corporation • 9700 NEWTON AVE. SO. • MINNEAPOLIS, MN 55431

DICOMED

COLOR FILM RECORDER

MODEL D48

OPERATION AND PROGRAMMING MANUAL

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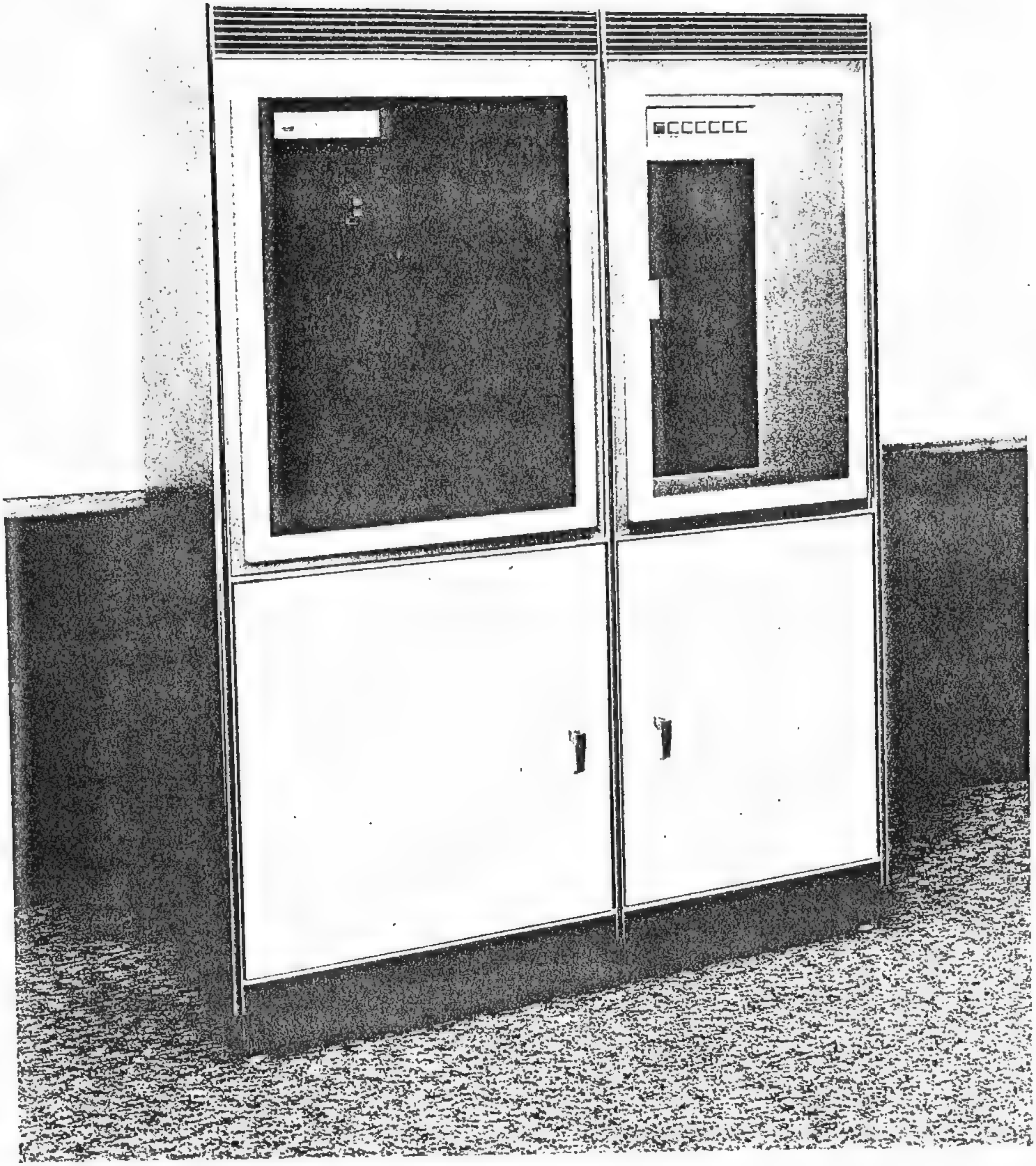


Figure 1-1. DICOMED D48 Film Recorder

SECTION 1

INTRODUCTION

1.1 SCOPE

This manual describes the DICOMED D48 Color Film Recorder with specific emphasis on operation and programming characteristics. The manual is divided into three basic sections:

1. INTRODUCTION which describes the general and functional characteristics of the D48,
2. OPERATION which familiarizes the readers with the operating procedures, and
3. PROGRAMMING which describes data word formats required when communicating with a computer.

A summary of safety precautions and installation guidelines is included in the appendixes.

1.2 GENERAL DESCRIPTION

The DICOMED D48 Color Film Recorder (hereafter referred to as the D48) is a computer output-to-film peripheral device. It is a unique device in that it can plot computer graphics (vector as well as shaded) and grey level picture information in full color. In addition, the D48 can be operated as a point plotter. With its precision, pin-registered film transport and magazine (camera), the D48 is ideally suited for computer animation, both scientific and commercial, as well as computer output to microfilm (COM) applications requiring the added dimension of color.

High resolution images (vector or raster pictures) are generated on the face of a precision cathode ray tube (CRT) and optically transferred via a specially designed color optics and filter system onto standard color photographic film.

The D48 is normally operated under full program control from a connected computer; however, an operator panel provides the controls for manual operation and calibration.

The functional characteristics of the D48 are described in the following paragraphs.

1.3 FUNCTIONAL DESCRIPTION

Upon receiving appropriate commands from a connected computer, the D48 plots vector or picture information onto 35mm or 70mm photographic film (other film sizes available) by plotting a series of individual points on a 4096 x 4096 point array in raster mode or 32,768 x 32,768 in vector mode (refer to Figure 1-2).

When operating in vector mode, three types of vectors, absolute long, relative long and relative short (described in Paragraph 1.3.3), are selectable from the computer and can be plotted at one of 256 exposure (brightness) levels.

When processing picture information (raster mode), each adjacent point (or element, described in Paragraph 1.3.1) may assume one of 256 exposure levels.

Color images (vectors and pictures) are generated by multiple exposures through one or more of seven color filters.

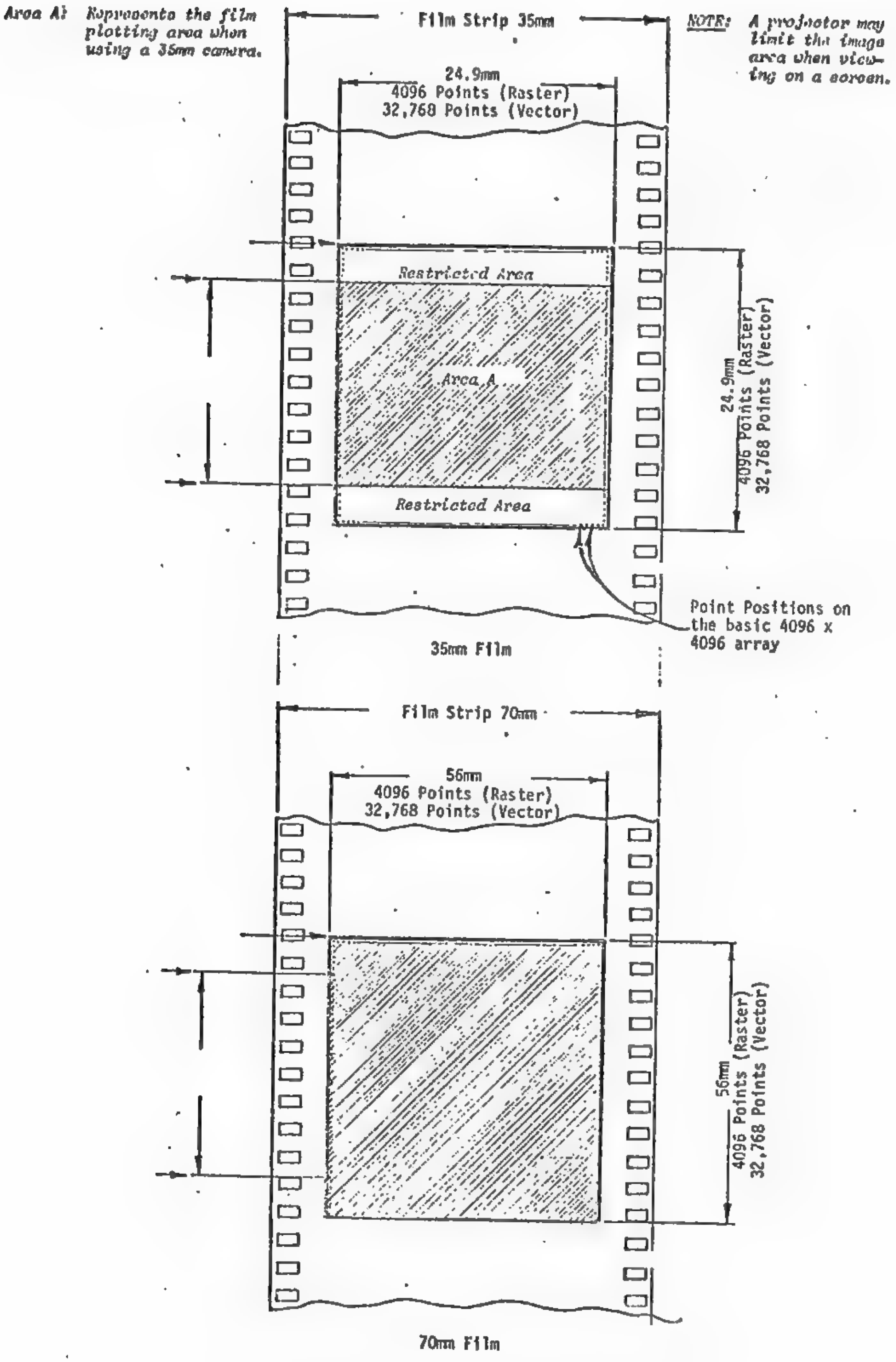
The D48 provides the user with flexibility in creating images (both vector and picture) on film in response to input words from the computer. The control functions which provide the flexibility are divided into the following groups:

...CRT Image Array Control
...Element Processing Control
...Vector Plotting Control
...CRT Beam Positioning Control
...Exposure Control
...Camera
...Word Formats
...Controls and Indicators
...Special Test Features

The functional characteristics of each of these groups are described in the following paragraphs.

1.3.1 CRT Image Array Control

Each image constructed on the face of the CRT (cathode ray tube) consists of an array of points plotted at specific exposure levels in response to commands from the connected computer. The basic image array on the D48 in raster mode consists of 4096 x 4096 points. The structure and orientation of the basic array, relative to the film, is illustrated in Figure 1-3. It should be noted that all references in this manual to horizontal and vertical directions with respect to film are as shown in Figure 1-3.



Area A: Represents the film plotting area when using a 35mm camera.

NOTE: A projector may limit the image area when viewing on a screen.

Figure 1-2. Film Plotting Area

For certain applications, it may be desirable to vary both the size of the basic point (and possibly the shape), as well as the spacing between points. The D48 has been designed to accommodate these requirements. In order to describe these features and the special characteristics associated with them, a new term will be introduced. The term is "element". Basically, an element is simply a cluster of individual points arranged in a specific order. Since the point or beam size of the CRT is constant, it becomes necessary to group a number of points to achieve multiple sizes. The following paragraphs describe the construction and positioning characteristics of an element.

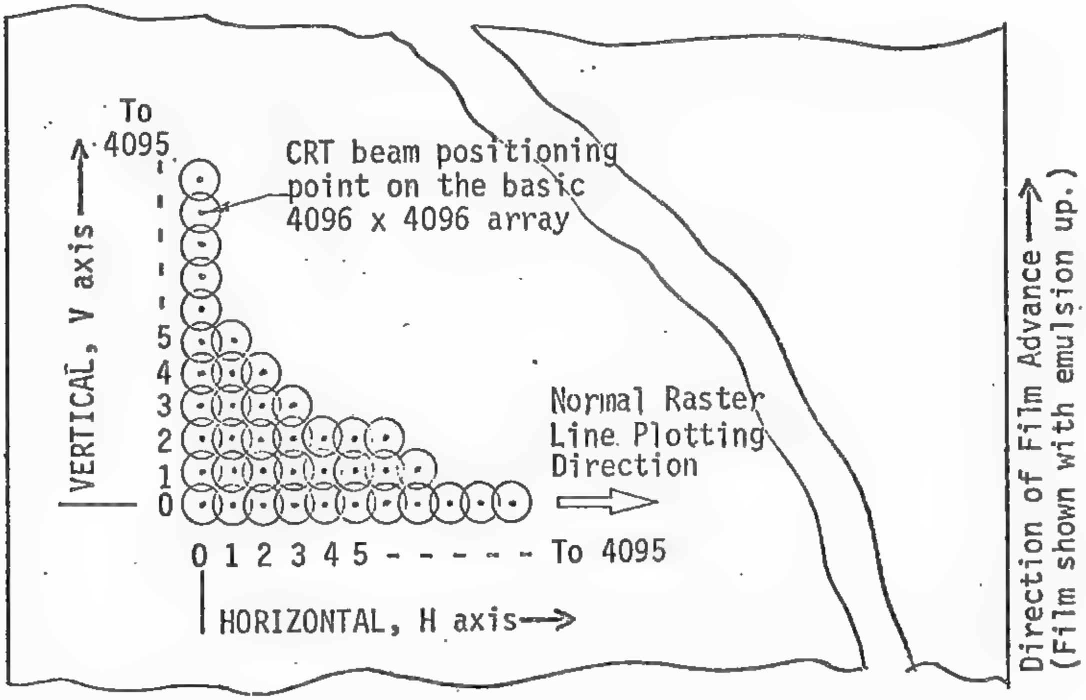

To 4095
VERTICAL, V axis
5
4
3
2
1
0
CRT beam positioning point on the basic 4096 x 4096 array
Normal Raster Line Plotting Direction
0 1 2 3 4 5 - - - - - - To 4095
HORIZONTAL, H axis
Direction of Film Advance
(Film shown with emulsion up.)

Figure 1-3. Basic Array Orientation

1.3.1.1 Element Construction

The construction of each element is made up of a square or rectangular array of points (within the basic 4096 x 4096 point array) that can vary from 1 to 16 points in both the horizontal and vertical directions. The number of points in both directions can be independently selected under computer control. Each point is plotted at the same exposure level.

1.3.1.2 Point Spacing

The distance between points that make up an element may be selected from a minimum of 1 basic point spacing on the 4096 x 4096 array to a maximum of 7 7/8 point spacings in increments of 1/8 of a basic point spacing (refer to Figure 1-4). It should be noted that the minimum spacing between points must equal or exceed 1 basic point spacing to minimize the overlapping of points. The point spacing can be independently selected in the horizontal and vertical directions under computer control.

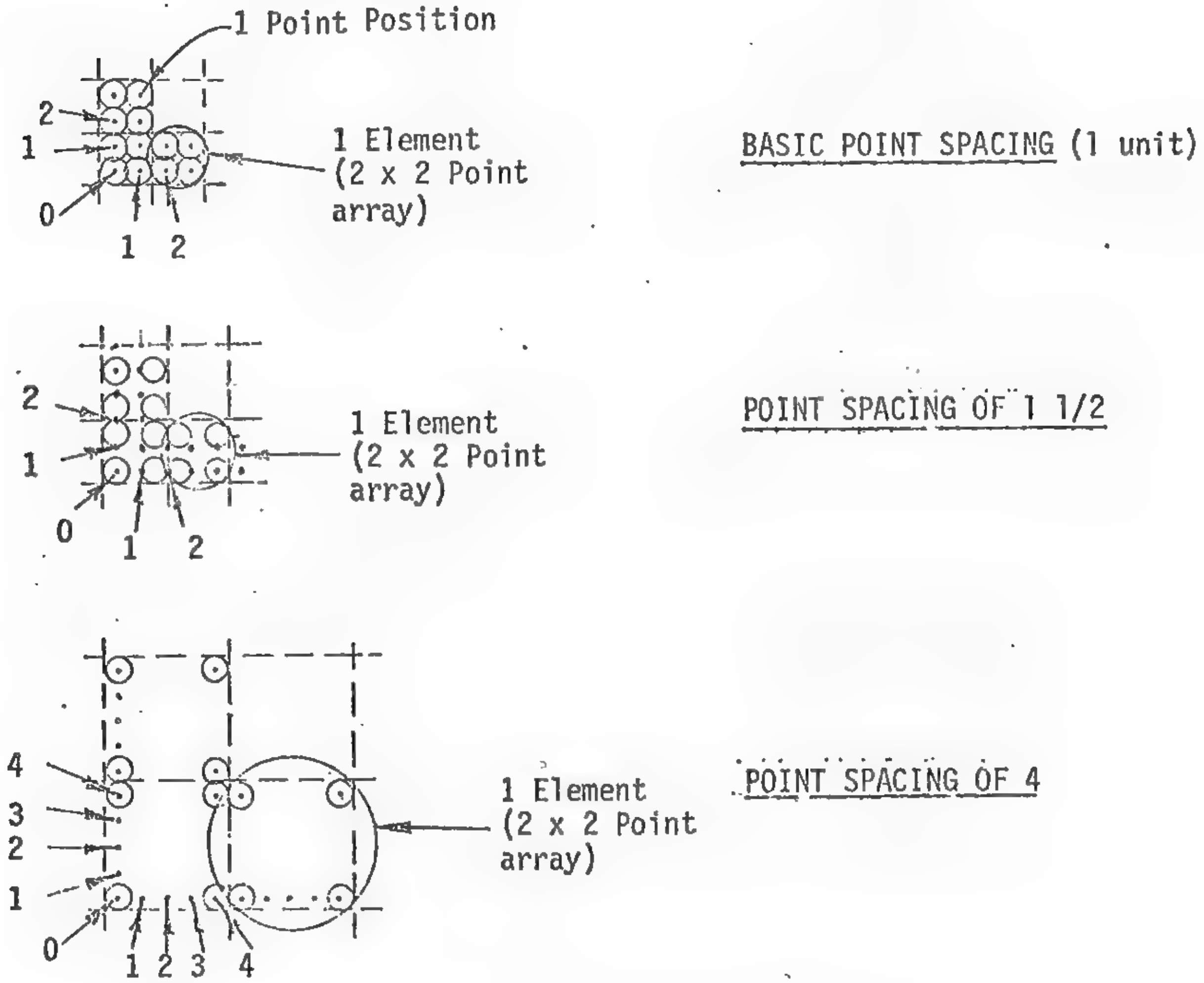
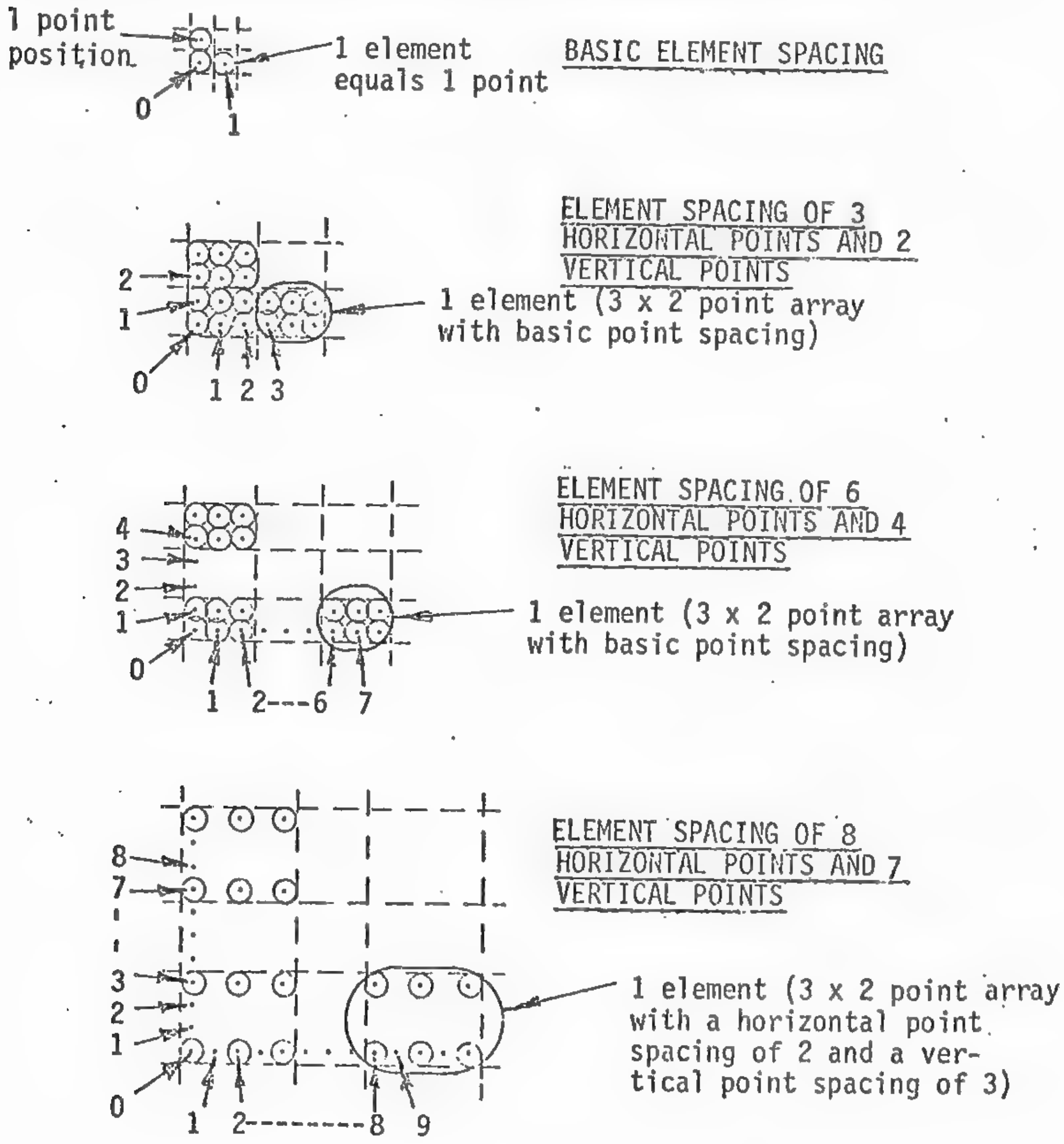

1 Point Position
2
1
0
1 2
1 Element (2 x 2 Point array)
BASIC POINT SPACING (1 unit)
2
1
0
1 2
1 Element (2 x 2 Point array)
POINT SPACING OF 1 1/2
4
3
2
1
0
1 2 3 4
1 Element (2 x 2 Point array)
POINT SPACING OF 4

Figure 1-4. Selected Point Spacing Examples

1.3.1.3 Element Spacing

The distance between each element may be selected from a minimum of one basic point spacing on the 4096 x 4096 point array to a maximum spacing of 15 7/8 points in increments of 1/8 of a basic point spacing. The number of point spacings is normally in reference to the lower left-hand corner of the previous element (refer to Figure 1-5). It should be noted that the element spacing must equal or exceed the number of points per element to prevent excessive overlapping of elements. The element spacing can be independently selected in both the horizontal and vertical directions under computer program control.



BASIC ELEMENT SPACING

ELEMENT SPACING OF 3 HORIZONTAL POINTS AND 2 VERTICAL POINTS

1 element (3 x 2 point array with basic point spacing)

ELEMENT SPACING OF 6 HORIZONTAL POINTS AND 4 VERTICAL POINTS

1 element (3 x 2 point array with basic point spacing)

ELEMENT SPACING OF 8 HORIZONTAL POINTS AND 7 VERTICAL POINTS

1 element (3 x 2 point array with a horizontal point spacing of 2 and a vertical point spacing of 3)

Figure 1-5. Element Spacing Examples

1.3.2 Element Processing Control

The D48 processes elements in four function modes:

1. raster,
2. adjacent element,
3. pattern element, or
4. single element,

selectable under program control. The mode is selected by interpreting a function code from the computer. The variable characteristics of each mode include:

...selectable exposure levels,
...selectable plotting directions, and
...number of elements processed per input word.

The characteristics are summarized for each mode in Table 1-1. The element processing modes are described in Paragraphs 1.3.2.1 through 1.3.2.4.

MODE	CHARACTERISTICS		
	EXPOSURE LEVELS	PLOTTING DIRECTIONS	ELEMENTS PER INPUT WORD
Raster	256*	1***	2
Adjacent Element	2**	8	4
Pattern Element	2**	1****	16
Single Element	256*	8	1

*64 in 6-bit mode.
**Any two exposure levels out of 256.
***Normally left to right, but may be altered using the Raster Reverse or H and V Axis Interchange Commands.
****Select one out of eight directions.

Table 1-1. Variable Element Processing Characteristics

1.3.2.1 Raster Mode

The D48, when operating in raster mode, accepts exposure codes from the computer, representing exposure levels for each element, and sequentially plots the information on a line-by-line basis on all, or any specified portion, of the basic 4096 x 4096 point array. The position and size of the image is determined by information in the operation input words from the computer. The starting point of the image within the basic array is determined by the position of the CRT (cathode ray tube) beam at the time of entry into the raster mode. The width of the raster (image) corresponds to the length of a horizontal raster line, which is variable, depending upon the number of elements selected in the operation word, the size of each element, and the element spacing. Each 16-bit function input word from the computer in raster mode represents exposure levels for two elements.

After each raster line is completed, the CRT beam returns to the starting position of the horizontal raster line plotted, and advances one element in the vertical direction in preparation for execution of the next line, if required. A delay is automatically provided at the end of each line to permit the CRT beam sufficient time to accurately position itself at the start of the next line. When short raster lines are required, this delay can be reduced under computer program control. The CRT beam may be prevented from returning to the start of the next horizontal line (eliminating the delay) by selecting the Flyback Disable feature.

The image can be altered in the raster mode by utilizing the following program selectable features:

> The image can be reversed by changing the direction of the horizontal raster line from left to right to right to left, and/or the vertical positioning from top to bottom to bottom to top; and
>
> the horizontal and vertical axis can be interchanged which causes the horizontal raster line to move in a vertical direction, and the line-by-line progression to move in a horizontal direction.

1.3.2.2 Adjacent Element Mode

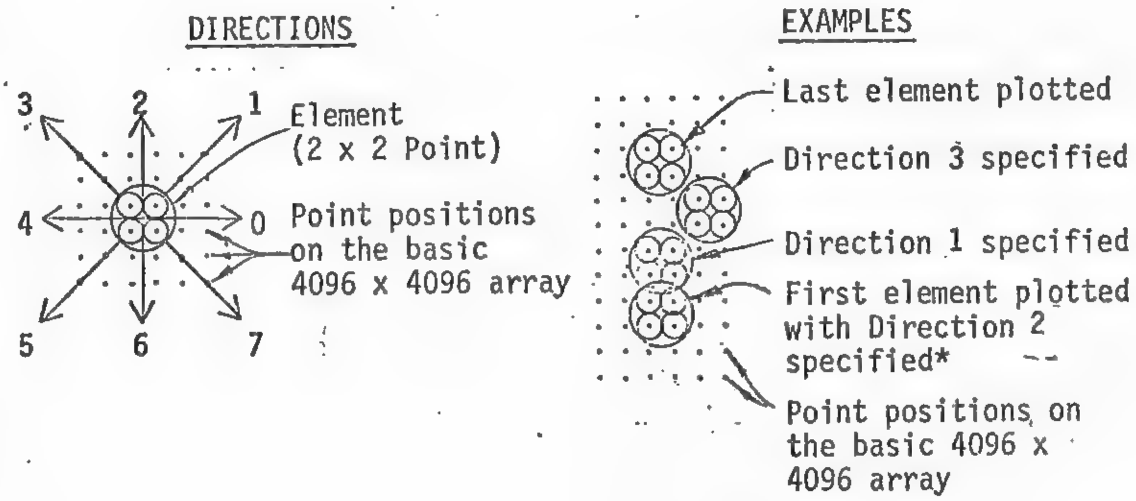
In adjacent element mode, the D48 plots bi-level elements at any of the eight program selectable directions from the current element position (refer to Figure 1-6). When in this mode, each element can be processed at either of two different exposure levels:

1. the level specified in the exposure code field of the input operation word from the computer, or

2. the zero exposure level.

It should be noted that the zero exposure level may be modified as explained in Paragraph 1.3.5.5.

Each 16-bit function input word can specify a new direction and one of the two exposure levels for each of four elements.



* The element is plotted at the current CRT beam position, and then the beam is repositioned in the specified direction for plotting the next element.

Figure 1-6. Adjacent Element Mode Directions and Examples

1.3.2.3. Pattern Element Mode

In pattern element mode, the D48 plots bi-level elements in a straight line on a bit-by-bit basis. Each element is processed using one of two exposure levels:

1. the level specified in the exposure code field of either the operation input word or the function input word from the computer, or

2. the zero exposure level.

It should be noted that the zero exposure level can be modified as explained in Paragraph 1.3.5.5.

The logical state of each bit in the input function word specifies one of the two exposure levels for each of 16 elements.

1.3.2.4 Single Element Mode

In single element mode, the D48 plots one element with each 16-bit function input word from the computer. Each word can select the following parameters or features for each element processed:

1. The move direction (refer to Figure 1-6).
2. The exposure level source (refer to "P field" under Paragraph 3.4.2.4).
3. The color filter.
4. The exposure code (one of 256).
5. The escape to the pattern element word format.

1.3.3 Vector Plotting Control

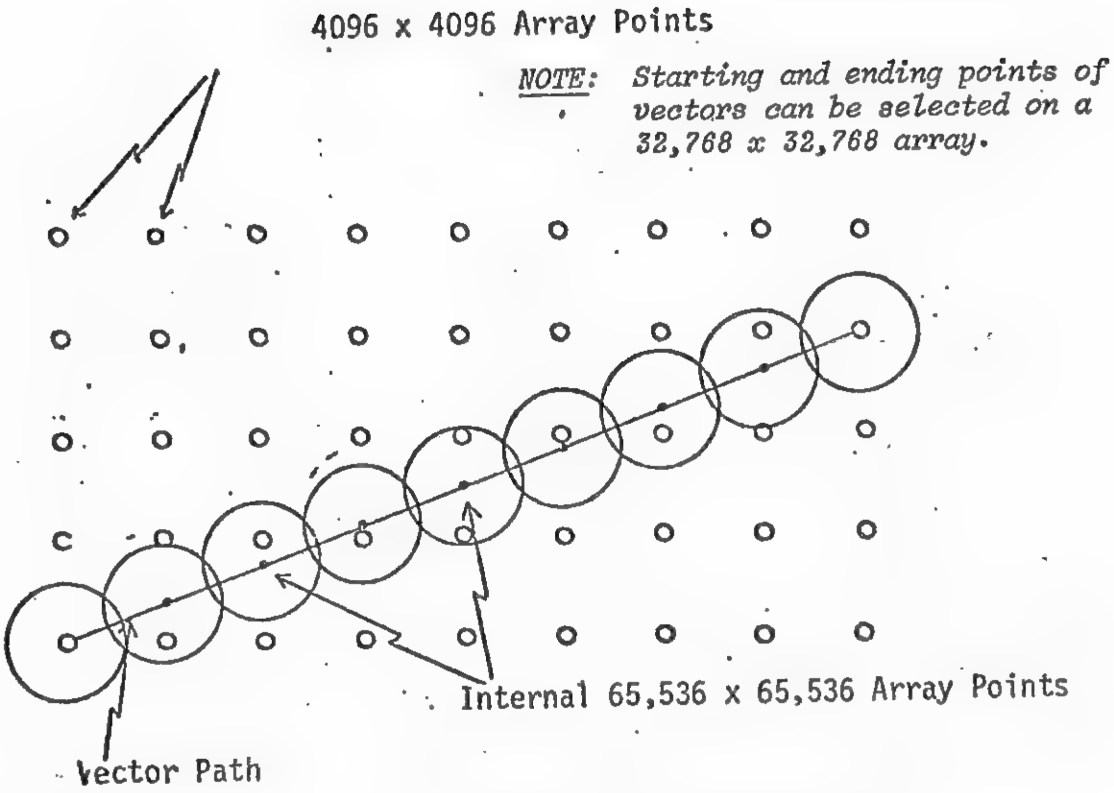
Vectors (directed straight lines) can be plotted between any two points within the 32,768 x 32,768 point array as specified by input words from the computer. The point by point plotting of a vector is internally plotted on a 65,536 x 65,536 point array creating very precise, straight lines (refer to Figure 1-7). There are three methods for generating vectors on the D48, each requiring a different input word format from the computer.

1. An absolute long vector, selected by an operation input word, can be drawn from the current CRT (cathode ray tube) beam position to any other specified position on the basic array.

2. A relative long vector, selected by an operation input word, can be drawn from the current CRT beam position for a distance corresponding to the resultant of the two orthogonal coordinate values (Δx and Δy).

3. A relative short vector, selected by a function input word, can be drawn in response to one 16-bit input word. The delta H and/or V can assume values in the range of 0 to 63 where a delta of "1" corresponds to 1 part out of 4096 of the total plotting area.

The input word formats, operation and function, are explained in Paragraph 1.3.7.



NOTE: Starting and ending points of vectors can be selected on a 32,768 x 32,768 array.

Figure 1-7. Vector 65,536 x 65,536 Point Array

1.3.4 CRT Beam Positioning Control

The CRT beam positioning capability in the D48 permits images to be constructed anywhere on the plotting area. Input words from the computer can specify horizontal and vertical coordinates that define the CRT beam destination position, or can specify position values that modify the current beam coordinates. The point plotting feature of the D48, if selected, permits a point to be plotted after the beam reaches the destination position. The input word formats for positioning the CRT beam are the same as for plotting vectors.

1.3.5 Exposure Control

The D48 utilizes a time modulated technique for exposing each element within an image on photographic film. Each element is assigned a digital value (exposure code) up to 255, proportional to the desired exposure level. The exposure code controls the CRT (cathode ray tube) beam "turn on" or unblanked time.

By selecting one or more of the seven color filters (red, blue, green, yellow, magenta, cyan and neutral), color images can be produced. A unique exposure control system compensates for the type of image (vector or raster) and the color filter selected to equalize exposure.

The D48 offers the following unique film exposure control features which are selectable by command codes or command fields:

...Log/Linear Exposure,
...6-Bit/8-Bit Exposure,
...Normal/Complement Exposure,
...Exposure Translation, and
...Background Exposure

The five features alter the interpretation of exposure codes received from the computer as described in the following paragraphs (1.3.5.1 - 1.3.5.5).

1.3.5.1 Log/Linear Exposure

The relationship of the exposure levels interpreted from the computer and the amount of exposure on film can be changed on the D48 under program control. In linear mode plotting, the amount of exposure on film is directly proportional to the exposure level. In log mode plotting, the amount of exposure on film is proportional to the logarithm of the exposure level.

1.3.5.2 6-Bit/8-Bit Exposure

The range of exposure codes representing exposure levels can be changed on the D48 from a maximum of 64 levels to 256 levels under program control. In 6-bit mode, 64 different exposure levels are selectable from the computer. When smaller increments between exposure levels are required, the D48 can be operated in the 8-bit mode which increases the number of selectable exposure levels to 256.

1.3.5.3 Normal/Complement Exposure

The D48 can interpret exposure codes, representing exposure levels from the computer, in two different ways. First, in NORMAL mode, the amount of exposure on photographic film increases (either linearly or logarithmically) with an increase in the exposure code value. Second, in COMPLEMENT mode, the amount of exposure on film increases as the exposure code decreases in value.

1.3.5.4 Exposure Translation

The D48 exposure translation feature provides the option of translating an exposure value or level (0 to 255) to another exposure value according to an exposure translation table contained in a programmable memory. Translation table memories are provided for red (R), green (G), and blue (B) filters.

1.3.5.5 Background Exposure

The D48 has two special programmable features that affect the amount of exposure on film when "zero" exposure level codes are received from the computer. First, a zero exposure code can be programmed to expose film at any one of 256 exposure levels. This feature is especially useful when creating bi-level images in the adjacent or pattern element modes (refer to Paragraphs 1.3.2.2 and 1.3.2.3, respectively). Secondly, a zero exposure code can either completely disable the CRT (cathode ray tube) beam, causing no exposure of film for that element, or enable the CRT beam to expose the film at the film fog level. The first feature, if selected, always has priority over the second feature.

1.3.6 Camera

The precision camera on the D48 (refer to Figure 1-8) consists of an optics module and a film transport that can be automatically controlled from the computer. The camera can be removed and replaced with different models to accommodate different film sizes and plotting areas. The standard film size is 35mm with a plotting area on the film of 24.9mm x 24.9mm, unless limited by the transport aperture. The optics module and film transport are described in Paragraphs 1.3.6.1 and 1.3.6.2, respectively.

1.3.6.1 Optics Module

The optics module includes color filters and a reduction lens. Seven color filters (red, blue, green, neutral, cyan, magenta and yellow) are provided on the D48 for generating multiple color images. Each filter has a matching color-corrected lens for achieving the proper focus and magnification of the CRT (cathode ray tube) image on the film plane.

1.3.6.2 Film Transport

The film transport (refer to Figure 1-9) is made up of the transport drive mechanism and the film magazine. The D48 monitors the film transport operation for malfunction (such as film buckling), and on request notifies the computer via an output status word that a problem exists.

The transport drive is designed to provide for positive film control at all times. The film movement is a positive registration type with fixed register pins. These pins are lapped to within .0001 inch to assure perfect registration when the same film is subjected to multiple exposure.

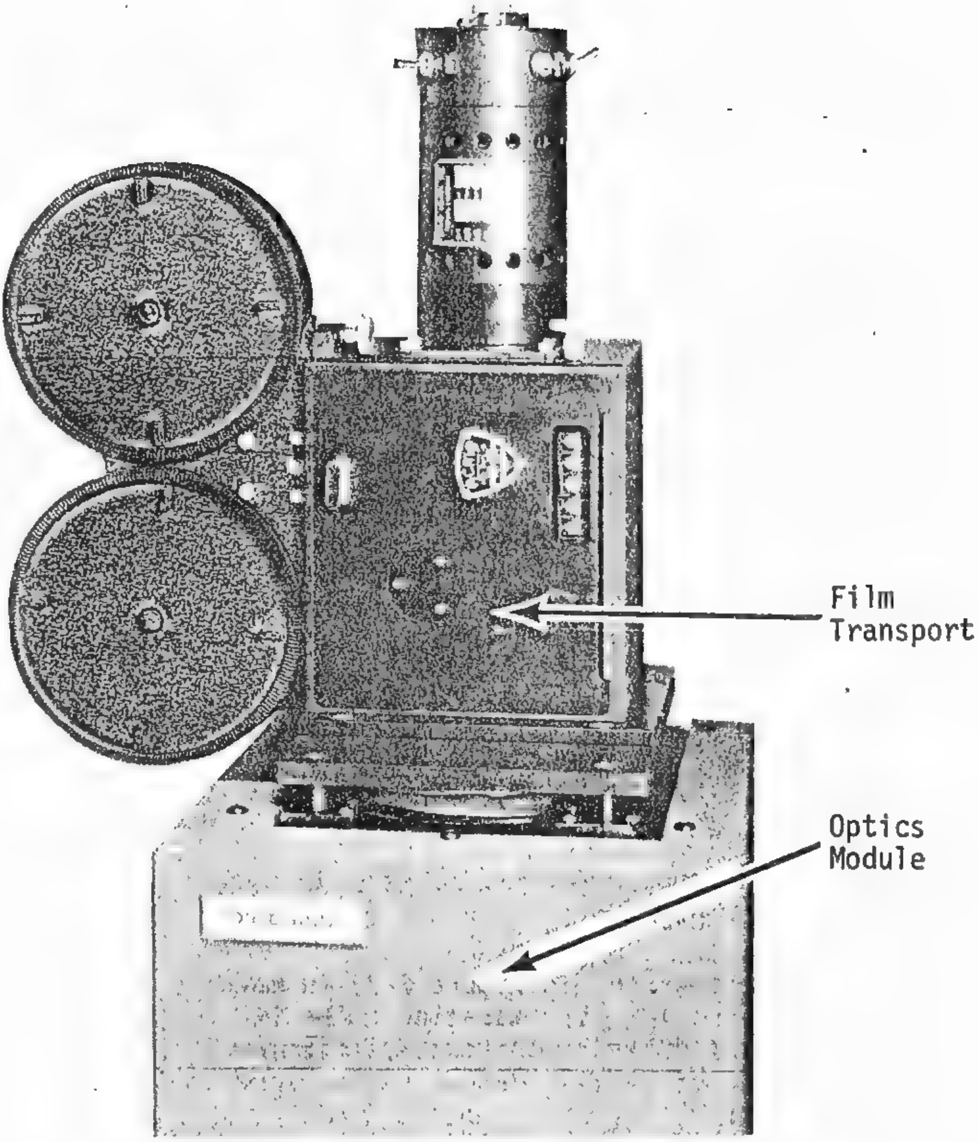


Figure 1-8. D48 Camera

Film advance is normally accomplished under program control, but may also be manually initiated from the operator panel. Input words from the computer can advance the roll film one frame at a time. A switch on the operator panel can disable the film advance mechanism which overrides any film advance commands from the computer. Disabling the film advance function permits computer program development without expensive film consumption. The transport drive can be changed to accommodate 35mm or 16mm film.

The standard film transport accommodates film magazines which hold up to 400 feet of 16mm or 35mm perforated film. Optional 1,000-foot supply and take-up film magazines can be accommodated. The film magazine can quickly be removed and reinstalled (refer to Paragraph 2.2.7), thus facilitating rapid film loading and unloading.

> NOTE: *Other film transports are available for applications where precision is not required. See Appendix D for description of 70mm film transport (F211) and 4 x 5 sheet film and Polaroid holders available for 70mm D48.*

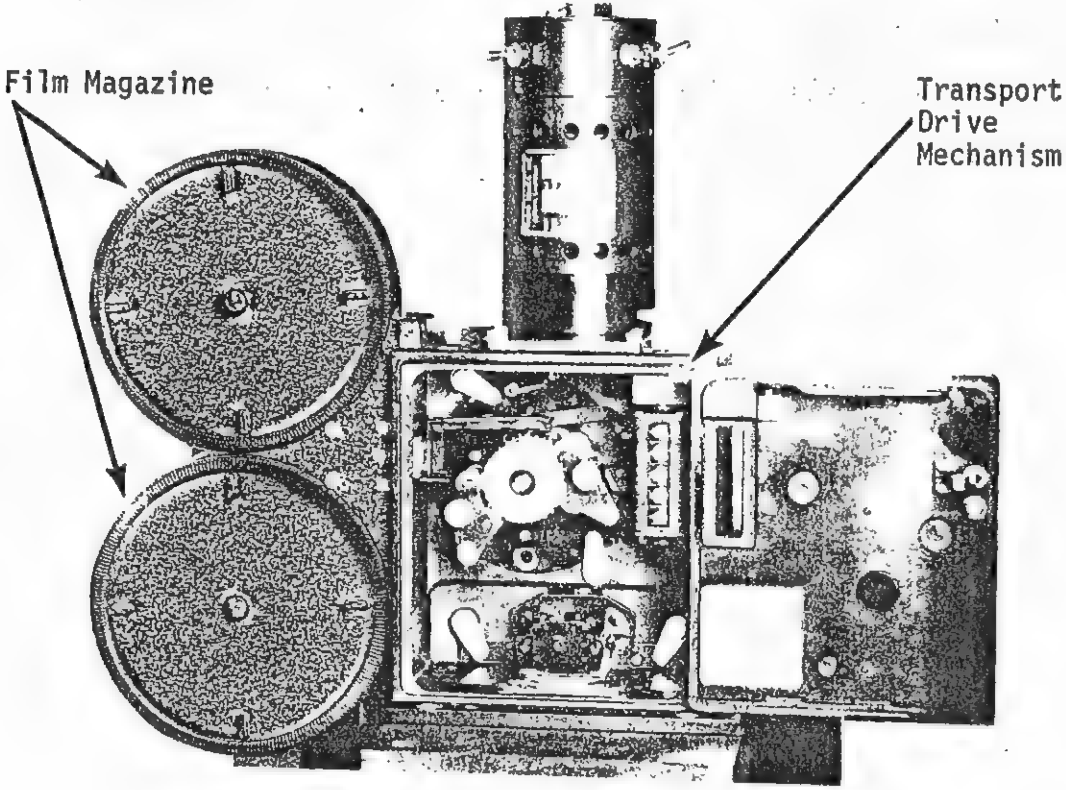


Figure 1-9. Film Transport

1.3.7 Word Formats

The D48 receives digital data and control information from the computer at the input channel in 16-bit word formats. Each input transfer is interpreted as an operation input word or a function input word.

The operation words normally contain information that conditions the D48 to:

...process picture information,
...plot vectors,
...plot points, or
...position the CRT (cathode ray tube) beam.

When processing picture information (elements), the operation word conditions the D48 to receive sequential function words which are required to further define commands and/or parameters to complete the required operation.

The detailed characteristics of input word formats, including a format summary illustration (refer to Figure 3-2), are described in Section 3, PROGRAMMING, Paragraph 3.4.

The D48 provides status information on the output channel in a 16-bit word format that can be transmitted to the computer on request. The status word format is described in Section 3, PROGRAMMING, Paragraph 3.3.

1.3.8 Controls and Indicators

Controls and indicators are provided on the D48 operator panel (refer to Figure 1-10) to permit an operator to monitor and manually control, if necessary, the total film plotting operation.

The fundamental controls and indicators for operating the D48 are located on the control panel above the sliding glass door. The remaining operator controls for specific operations are located on the test and calibration panel behind a sliding glass door. The function of each switch, indicator and control for both panels is described in Paragraphs 1.3.8.1 and 1.3.8.2.

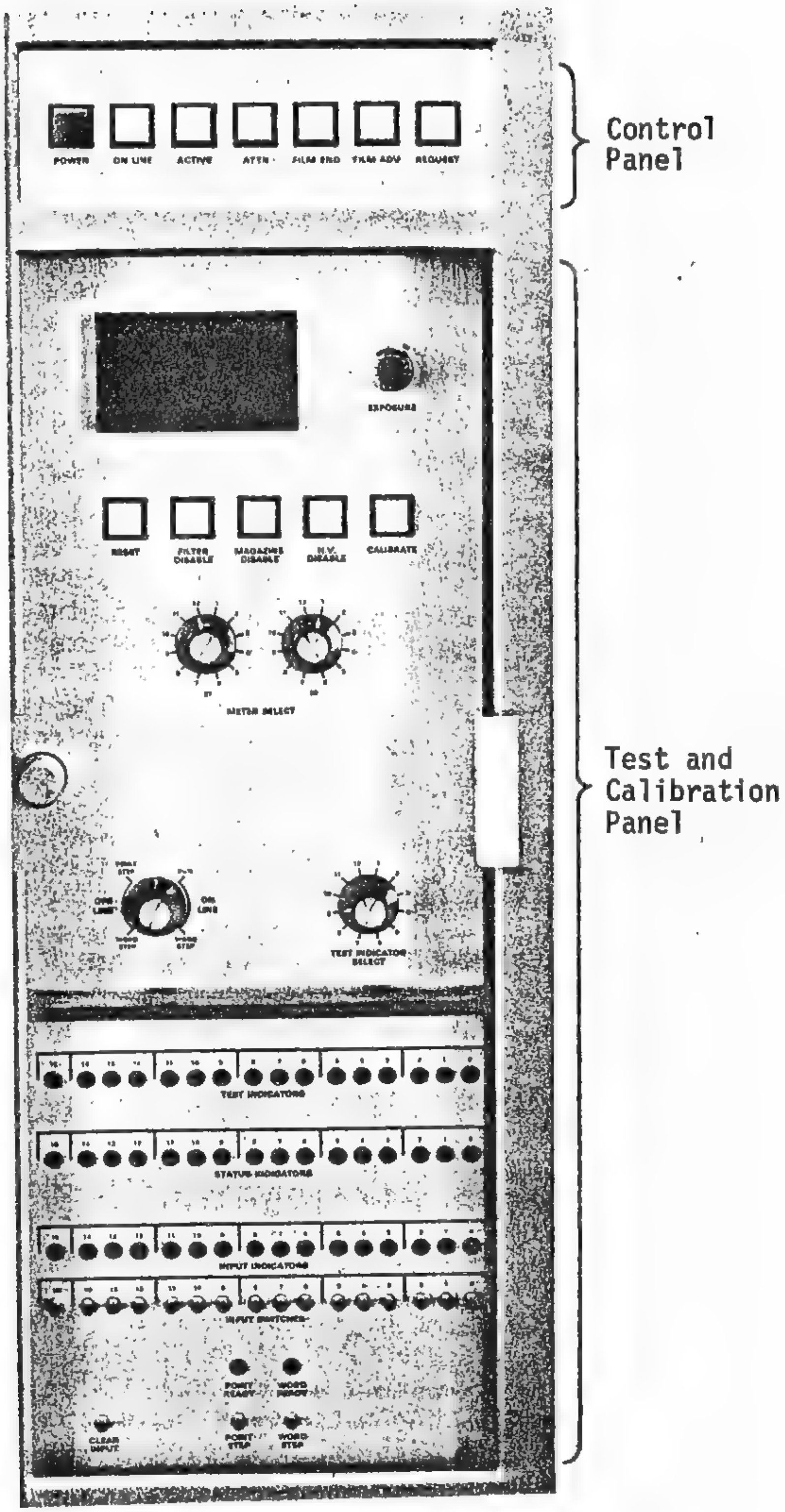


Figure 1-10. Operator Panel

1.3.8.1 Control Panel

The four indicators and three combination switch/indicators along the top of the operator panel (refer to Figure 1-10) enable the user to operate the D48. The function of each switch and indicator is described below:

POWER: The POWER switch/indicator consists of an alternate action switch which controls the application of input A.C. power to the D48, and includes a green indicator which is illuminated when power is applied. This switch is enabled for power by a key switch located adjacent to the main circuit breaker on the power panel.

ON-LINE: The white ON-LINE indicator illuminates when the ON-LINE/OFF-LINE switch on the test and calibration panel is in the ON-LINE, RUN position. When the indicator is illuminated, the D48 is under control of the connected computer.

ACTIVE: The white ACTIVE indicator illuminates when the D48 is processing information from the computer or from the operator panel.

ATTN: The yellow ATTN (attention) indicator illuminates and extinguishes under computer program control. It can be used to notify the operator that the computer has received a status word indicating a potential problem with the D48.

FILM END: The yellow FILM END indicator illuminates when the film magazine is out of film.

FILM ADV: The FILM ADV (film advance) switch/indicator consists of a momentary switch which causes the film transport to advance the film one frame. The white indicator illuminates during the time that the film mechanism is moving the film.

REQUEST: The REQUEST switch/indicator consists of a momentary switch which is enabled by a command from the computer. When the switch is enabled, the yellow indicator illuminates. Depressing the switch with the indicator illuminated sets the "Request" bit in the output status word.

1.3.8.2 Test and Calibration Panel

The switches, indicators and controls on the test and calibration panel (refer to Figure 1-10) provide a means for monitoring and manually controlling all the operating functions of the D48 that are normally performed by the computer. In addition, several functions can be performed manually that:

1. calibrate the light output of the CRT (cathode ray tube), and

2. test several operating voltages and logic signals which aid in performing maintenance.

The function of each switch, indicator and control is described below:

DIGITAL READOUT:	The DIGITAL READOUT display is a 3 1/2 digit panel meter used for monitoring various conditions or voltage parameters within the D48 as determined by the position of the METER SELECT switches (see Table 1-2).
EXPOSURE:	The EXPOSURE adjustment consists of a 10-turn potentiometer connected to a 10-turn counting dial which provides a means of calibrating the intensity of the light beam on the face of the CRT.
RESET:	The RESET switch/indicator consists of a momentary switch which causes the D48 to revert to the basic operating state. Depressing this switch initializes the control logic, clears the status bits, and clears the ATTN (attention) indicator. The white RESET indicator illuminates as long as the switch is depressed.
FILTER DISABLE:	The FILTER DISABLE switch/indicator consists of a yellow indicator and an alternate action switch which enables or disables the execution of filter select commands. In the disabled state, all filter select commands are ignored and the indicator is illuminated. In the enabled state, the filter commands are executed and the indicator is extinguished.

MAGAZINE DISABLE:	The MAGAZINE DISABLE switch/indicator consists of a yellow indicator and an alternate action switch which enables or disables the execution of film advance commands. In the disabled state, all film advance commands are ignored and the indicator is illuminated. In the enabled state, the film advance commands are executed and the indicator is extinguished.
H.V. DISABLE:	The H.V. DISABLE (high voltage) switch/indicator consists of a yellow indicator and an alternate action switch which enables or disables the CRT high voltage power supply. In the disabled state, the high voltage is OFF and the indicator is illuminated. In the enabled state, the high voltage is ON and the indicator is extinguished. It should be noted that the indicator will be illuminated whenever high voltage is missing. The absence of high voltage may be caused by an abnormal condition, operating in the calibrate mode, or placing the HIGH VOLTAGE switch on the Power Panel in the OFF position. The H.V. DISABLE switch function is normally only used during maintenance or initial program debugging to prevent any damage to the CRT screen.
CALIBRATE:	The CALIBRATE switch/indicator consists of a yellow indicator and an alternate action switch which selects the calibrate mode. The indicator illuminates approximately three seconds after the calibrate mode is selected. When illuminated, a relative number representing the exposure value appears on the DIGITAL READOUT display. An operator can now change this exposure value, if required, by adjusting the EXPOSURE potentiometer. The calibrate mode is terminated by depressing the CALIBRATE switch, extinguishing the indicator.
METER SELECT:	The two 12-position rotary METER SELECT switches (S1 and S2) select the voltage parameters represented on the DIGITAL READOUT display. Table 1-2 lists the parameters for all the switch positions.

METER SELECT SWITCH POSITIONS		PARAMETERS
S1 Setting	S2 Setting	
1	any	+5 Volt D.C.
2	"	-5 Volt D.C.
3	"	+6.3 Volt D.C.
4	"	+15 Volt D.C.
5	"	-15 Volt D.C.
6	"	+120 Volt D.C.
7	"	-120 Volt D.C.
8	"	+36 Volt D.C.
9	"	-36 Volt D.C.
10	"	25KV High Voltage
11	"	2KV
12	1	CRT Grid 1 Voltage
12	2	CRT Cathode Voltage
12	3	Static Focus Current
12	4	H-Deflection
12	5	V-Deflection
12	6	H-Centering
12	7	V-Centering
12	8	-30 Volt D.C.

Table 1-2. Displayed Voltage Parameters

ON-LINE/OFF-LINE: The ON-LINE/OFF-LINE four-position rotary switch controls the source of data words and the halt breakpoints of the D48. The function of each switch position is described in Table 1-3. These functions are useful in program debugging and maintenance.

SWITCH POSITION		FUNCTION
OFF LINE	POINT STEP	The data source is manually loaded from the INPUT SWITCHES on the lower part of the test and calibration panel. The D48 halts at the end of each point plotted. The POINT STEP push-button switch is used to manually process one point per switch depression.
	WORD STEP	The data source is manually loaded from the INPUT SWITCHES on the lower part of the test and calibration panel. The D48 halts after the execution of each input data word. The WORD STEP push-button switch is used to manually process one word per switch depression.
ON-LINE	RUN	The data source is the computer input channel. The D48 executes all input words without any breakpoints.
	WORD STEP	The data source is the computer input channel. The D48 halts after the execution of each input word. The WORD STEP push-button switch is used to manually process one word per switch depression.

Table 1-3. ON-LINE/OFF-LINE Switch Functions

POINT READY:	The POINT READY indicator illuminates when the ON-LINE/OFF-LINE switch is in the POINT STEP position, and the D48 logic is ready to execute the next point exposure operation. The indicator extinguishes whenever either one of the above conditions is not met.
POINT STEP:	The POINT STEP switch, when depressed with the POINT READY indicator illuminated, initiates the next point exposure operation.
WORD READY:	The WORD READY indicator illuminates when the ON-LINE/OFF-LINE switch is in one of the WORD STEP positions, and the D48 logic is ready to execute the next input word.
WORD STEP:	The WORD STEP switch, when depressed with the WORD READY indicator illuminated, initiates the execution of the next input word.
CLEAR INPUT:	The CLEAR INPUT switch, when depressed with the ON-LINE/OFF-LINE switch in the OFF-LINE, POINT STEP or WORD STEP position, clears the bits in the INPUT INDICATORS register on the test and calibration panel.

INPUT SWITCHES:	The 16 push-button INPUT SWITCHES are used to enter input data into the D48 input register when operating in the off-line mode (ON-LINE/OFF-LINE switch in the OFF-LINE position).
INPUT INDICATORS:	The 16 INPUT INDICATORS display the contents of the input data register which normally contains the next input word to be executed by the D48. In the on-line mode, the information is received from the computer. In the off-line mode, the information is received from the INPUT SWITCHES on the test and calibration panel.
STATUS INDICATORS:	The 16 STATUS INDICATORS display the contents of the status register which contains the operating status bits of the D48 that, when requested, get transferred to the computer via the output data channel.
TEST INDICATORS:	The 16 TEST INDICATORS display the state of 12 sets of logic conditions in the D48 (refer to Table 1-4). Each set is selected by the TEST INDICATOR SELECT switch on the test and calibration panel.
TEST INDICATOR SELECT:	The 12-position rotary TEST INDICATOR SELECT switch selects the set of logic conditions (1 of 12) that will be displayed on the TEST INDICATORS. The selectable set of logic conditions are listed in Table 1-4.

<table>
<tr><th rowspan="14">TEST INDICATOR SELECT SWITCH POSITIONS</th><th></th><th colspan="16">TEST INDICATOR BITS</th></tr>
<tr><th></th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>1</td><td colspan="16">H Position</td></tr>
<tr><td>2</td><td colspan="16">V Position</td></tr>
<tr><td>3</td><td colspan="8">Exposure Register</td><td colspan="8">Exposure Code to Grid Timing Card</td></tr>
<tr><td>4</td><td colspan="3">Filter Code</td><td>Busy</td><td>Track</td><td>☒</td><td colspan="10">Filter Wheel Position</td></tr>
<tr><td>5</td><td>Word 3</td><td>Word 2</td><td>Word 1</td><td>ES</td><td colspan="12">Element Count</td></tr>
<tr><td>6</td><td colspan="16">Pattern Shift Register</td></tr>
<tr><td>7</td><td colspan="16">H Delta Register</td></tr>
<tr><td>8</td><td colspan="16">V Delta Register</td></tr>
<tr><td>9</td><td colspan="3">Move Code</td><td colspan="7">H Element Spacing</td><td colspan="6">H Point Spacing</td></tr>
<tr><td>10</td><td colspan="3">Function Code</td><td colspan="7">V Element Spacing</td><td colspan="6">V Point Spacing</td></tr>
<tr><td>11</td><td colspan="8">Background Exposure</td><td colspan="4">H Points per Element</td><td colspan="4">V Points per Element</td></tr>
<tr><td>12</td><td>D</td><td>C</td><td>B</td><td>A</td><td colspan="12">Initial Condition Select</td></tr>
</table>

A - ON implies B/W exposure selected.
B - ON implies line exposure selected.
C - ON implies B/W translation enabled.
D - ON implies color translation enabled.

Table 1-4. Displayed Logic Test Parameters

1.3.9 Special Features

The D48 features two special hard-wired operating modes, prime and test, that are designed to assure the user of satisfactory equipment operation. Both modes are program selectable from the computer using operation input words specifying the appropriate command code. The prime and test modes are described in Paragraphs 1.3.9.1 and 1.3.9.2, respectively.

1.3.9.1 Prime Mode

The prime mode in the D48 provides a method of eliminating residual image retention on the CRT (cathode ray tube) phosphor that may result from repetitive plotting of the same image.

1.3.9.2 Test Mode

The test mode provides a convenient method of generating a test pattern on film. The test pattern image checks some of the internal logic and checks the photometric and geometric image quality. The test mode is normally initiated when first applying power to the D48 or at the beginning of a job.

SECTION 2

OPERATION

2.1 SCOPE

This section describes the D48 operating procedures for generating images on film. Included are procedures for testing, priming, and calibrating the D48.

2.2 BASIC OPERATION

The D48 is a programmable device that permits continuous film plotting operations without operator intervention. An operator, before operating under computer control, must:

1. Apply A.C. input power.
2. Load the camera with film.
3. Calibrate the exposure.
4. Rotate the OFF-LINE/ON-LINE switch to the ON-LINE, RUN position.
5. Press the RESET switch.
6. Check the status indicators.

When first applying A.C. power to the D48, it is recommended that certain voltages be checked using the switches on the test and calibration panel. If any of the voltages are of an incorrect value, the problem should be resolved before proceeding. The voltage check procedure is included in Paragraph 2.2.2.

The operating status of the D48 is checked by observing the STATUS INDICATORS on the test and calibration panel. The function of each bit is described in Section 3, Table 3-1. Before operating from the computer, assure that the indicators are extinguished. Indicators 2, 3, or 4 may be illuminated if the corresponding disable switch (MAGAZINE DISABLE, FILTER DISABLE, or H.V. DISABLE, respectively) has been depressed. Any of the other indicators illuminated indicates that corrective action is required before proceeding.

Certain applications may require operating the D48 in the prime mode periodically to remove residual image retention that may occur when repetitively plotting a high contrast image. Retention is due to an increased sensitivity of the CRT (cathode ray tube) phosphor in the areas previously plotted. "Priming" the CRT reduces this retention by plotting a full format image at the maximum exposure level. The prime mode can be initiated under computer program control or by using switches on the test and calibration panel (refer to Paragraph 2.2.5).

The photometric and geometric image quality of the D48 can periodically be checked by generating an internal test pattern. The test pattern can be generated under computer program control or by using switches on the test and calibration panel (refer to Paragraph 2.2.4).

2.2.1 Power-On Procedure

The POWER switch/indicator on the control panel applies power to the D48 when enabled by the POWER key switch and circuit breaker located on the power panel (refer to Figure 2-1). The FILAMENT indicator on the power panel illuminates whenever the input power plug is plugged into a power source, and the circuit breaker is in the ON position. The illuminated FILAMENT indicator indicates that the CRT (cathode ray tube) filament voltage is on.

> NOTE: *It is recommended that the D48 filament voltage remain on at all times. Keeping the filament voltage on stabilizes the light output of the CRT, requiring less frequent exposure calibration adjustments.*

2.2.2 Voltage Check Procedure

The D48 power supply voltages can be monitored on the test and calibration panel. The voltages are checked by rotating the METER SELECT switches (S1 and S2) on the test and calibration panel and viewing the digital display. The values for each switch position should be compared with those listed in Table 2-1.

> NOTE: *If any of the voltages are not within range, contact a DICOMED Customer Service representative before proceeding.*

METER SELECT SWITCH POSITIONS		DIGITAL DISPLAY READING	
S1 Setting	S2 Setting	Minimum Allowable	Maximum Allowable
1	any	+4.8	+5.2
2	any	-4.8	-5.2
3	any	+5.9	+6.5
4	any	+14.7	+15.3
5	any	-14.7	-15.3
6	any	+110.0	+130.0
7	any	-110.0	-130.0
8	any	+34.0	+45.0
9	any	-34.0	-45.0
11	any	+190.0	+210.0
12	8	-29.0	-31.0

Table 2-1. Power Supply Voltages

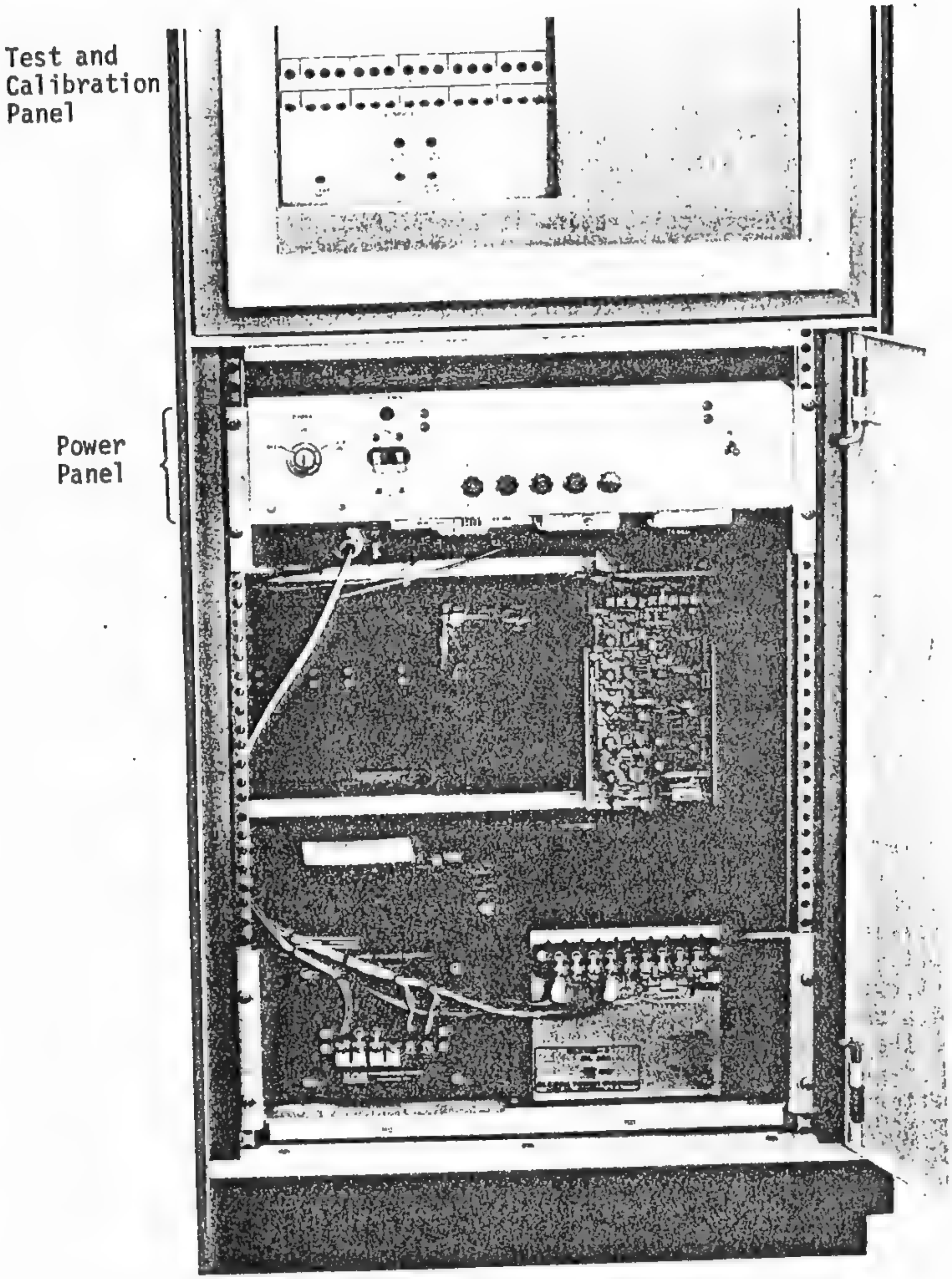


Figure 2-1. Power Panel

2.2.3 Exposure Calibration Procedure

Exposure calibration on the D48 is required:

- whenever initially applying A.C. input power, and periodically during normal daily operations (suggested two or three times during every eight hours of operation).

The procedure for exposure calibration is as follows:

1. Press the CALIBRATE switch/indicator on the test and calibration panel. After a three-second delay, the indicator illuminates, and the exposure value can be viewed on the digital display.

2. Adjust the EXPOSURE control knob on the test and calibration panel until the digital display indicates the proper exposure value.

   NOTE: An initial exposure value is provided with each D48.

3. Calibration is now complete. Press the CALIBRATE switch, and the CALIBRATE indicator should extinguish.

2.2.4 Test Pattern Generation Procedure

An internally generated test pattern provides a convenient method for verifying photometric and geometric image quality on the D48.

The test pattern is an 8 x 8 checkerboard occupying the complete plotting matrix. Each checkerboard square consists of a series of scan lines, each having constant intensity. The intensity of the scan lines increases or decreases vertically to represent all 256 exposure values. Adjacent squares are constructed in complementary sequence to provide the 8 x 8 format. Although not apparent to the unaided eye, each square in the 8 x 8 grid is composed of a smaller point checkerboard in a 2 x 2 format. Figure 2-2 illustrates the format of the test pattern.

The test pattern can be initiated automatically under program control (refer to PROGRAMMING SECTION) or manually from the test and calibration panel.

The procedure for manually generating the test pattern is as follows:

1. Calibrate the exposure following the procedure in Paragraph 2.2.3.

2. Verify that the camera magazine is loaded with film and mounted on the camera (refer to Paragraphs 2.2.6 and 2.2.7).

3. Press the RESET switch on the test and calibration panel.
4. Rotate the OFF-LINE/ON-LINE switch on the test and calibration panel to the OFF-LINE, WORD STEP position.
5. Press the INPUT SWITCHES 0 and 2 on the test and calibration panel. The indicators above Switches 0 and 2 should be illuminated.
6. Press the WORD STEP switch on the test and calibration panel. The ACTIVE indicator on the control panel will be illuminated until the test pattern is complete.

The D48 can be returned to the computer controlled condition by:

1. rotating the OFF-LINE/ON-LINE switch to the ON-LINE, RUN position, and
2. pressing the RESET switch.

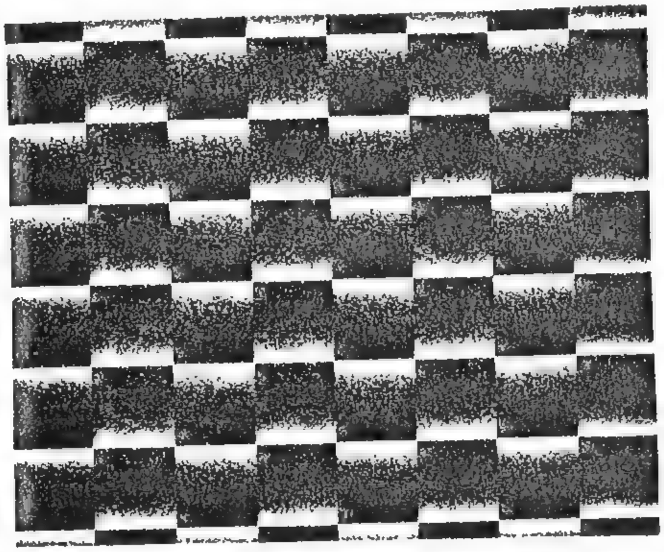


Figure 2-2. Test Pattern

2.2.5 Prime Mode Procedure

The prime mode can be initiated automatically under program control (refer to PROGRAMMING Section) or manually from the test and calibration panel.

The procedure for manually priming the CRT is as follows:

1. Rotate the OFF-LINE/ON-LINE switch on the test and calibration panel to the OFF-LINE, WORD STEP position.
2. Calibrate the exposure to the highest recommended exposure value (refer to Paragraph 2.2.3).
3. Press the INPUT SWITCH 2 on the test and calibration panel. The indicator above Switch 2 should be illuminated.
4. Press the WORD STEP switch on the test and calibration panel. The ACTIVE indicator on the control panel will be illuminated until the priming is complete.

The D48 can be returned to the computer controlled condition by:

1. rotating the OFF-LINE/ON-LINE switch to the ON-LINE, RUN position, and
2. pressing the RESET switch.

2.2.6 Film Magazine Loading Procedure

The film magazine supply compartment must be loaded in a darkroom. The film used must be wound on standard two-inch diameter plastic cores with the emulsion on the inside. The film can be loaded by using the following procedure (refer to Figure 2-3).

1. Remove the supply compartment cover and the take-up compartment cover.
2. Install the roll of film on the spindle as shown in Figure 2-3.
3. Thread the end through the light trap rollers.
4. Reinstall the supply compartment cover.

The remainder of the procedure does not require a darkroom.

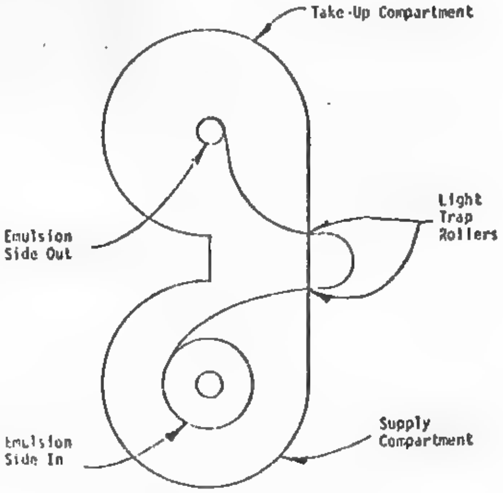


Figure 2-3. Film Magazine Loading

5. Thread the film into the take-up compartment.

6. Fasten the film to a two-inch diameter plastic core such that the emulsion is on the outside.

7. Reinstall the take-up compartment cover.

8. The magazine is now ready for mounting on the film transport drive mechanism (refer to Paragraph 2.2.7).

2.2.7 Film Magazine Installation Procedure

The magazine can be mounted on the film transport drive mechanism by using the following procedure (refer to Figure 2-4):

1. Open film transport door by rotating knob.

2. Place the motor FWD/OFF/REV switch in the OFF position.

CAUTION

Failure to put the motor switch in the OFF position may cause injury to personnel or damage to equipment.

3. Pull approximately two feet of film from the magazine supply compartment.

4. Insert film loop through access hole in camera.

5. Secure magazine by placing in mounting slot, pressing down and tightening thumbscrew.

6. Release upper and lower film keepers by pulling lock knob towards operator.

   NOTE: Refer to diagram on the inside of the camera door for film threading path.

7. Rotate motor knob until pressure plate cycles away from the film plane.

8. Retract pulldown pins by moving film release button along slotted path.

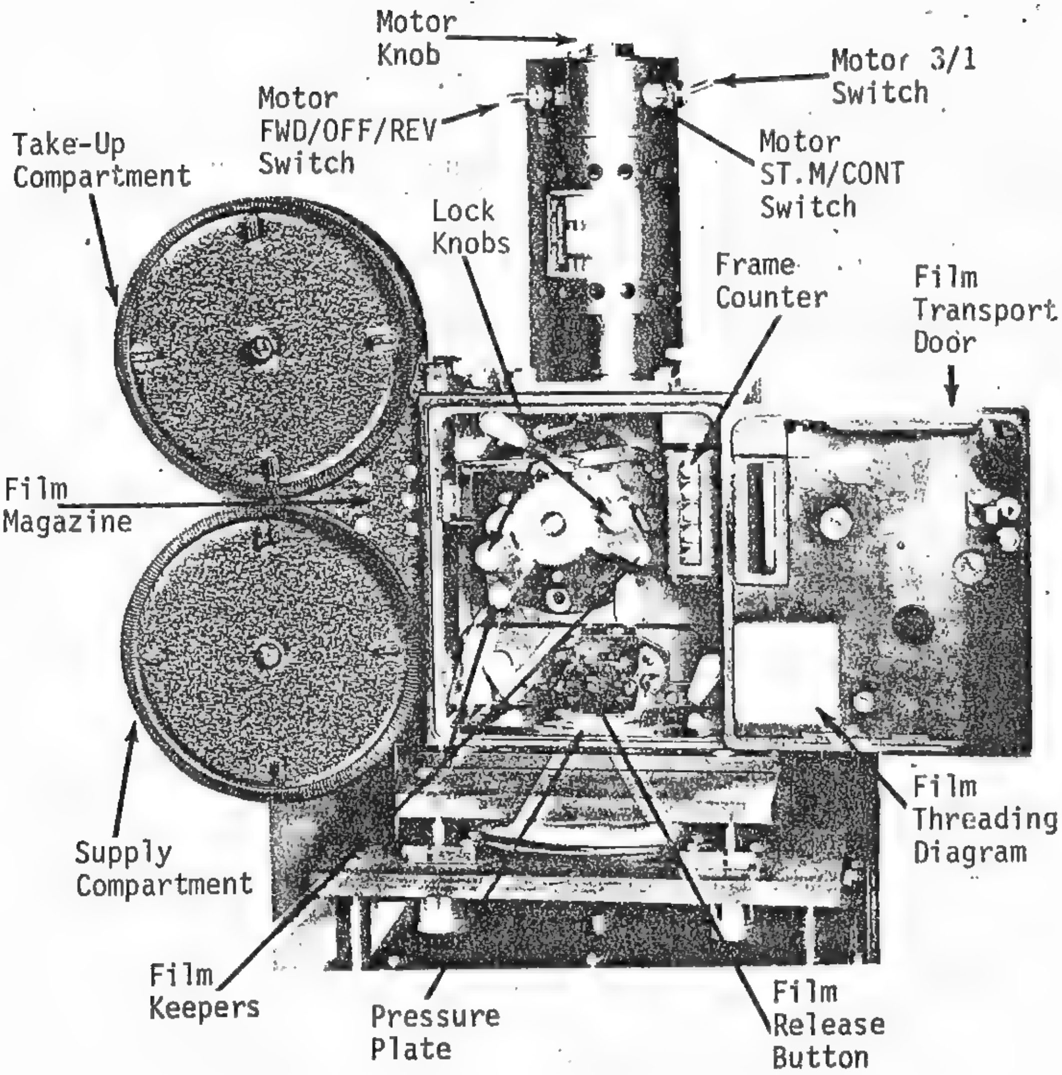


Figure 2-4. Film Magazine Installation

9. Position film in pressure plate until pull-down pins are aligned with any two perforations, and then release button.

> ***CAUTION***
>
> *Ensure that film loops do not touch the case or restrict the film in movement or film damage will occur.*

10. Adjust film to form loops by positioning on sprocket teeth.
11. Close and lock upper and lower film keepers.
12. Close film transport door.
13. Install take-up belt on back of magazine.
14. Place the motor ST.M/CONT switch in the ST.M position.
15. Place the motor 3/1 switch in the 1 position.
16. Place the motor FWD/OFF/REV switch in the FWD position.
17. Generate a leader by placing the motor ST.M/CONT switch to the CONT position for 25 frame advances (50 for 16mm). Use the frame counter to determine the correct number of advances. This operation moves the unexposed film into the aperture area.

2.2.8 Film Magazine Removal Procedure

After plotting a few images on film, the film magazine can be removed without exposing the rest of the unused roll by the following procedure:

1. Press the FILM ADV (Film Advance) switch approximately 25 times for 35mm film (50 times for 16mm), or place the motor ST.M/CONT switch in the CONT position until the appropriate number of frames has advanced. Use the frame counter to observe the frame count.
2. Open film transport door by rotating knob.
3. Cut film where it enters and leaves camera (two places).
4. Remove belt on back of magazine.

5. Loosen magazine by rotating thumbscrew on top of film transport while lifting the magazine.

6. Take magazine to darkroom for processing.

2.2.9 Manual Operating Procedure

When not operating from a computer (on-line), the D48 can be operated via the switches on the test and calibration panel (off-line). The OFF-LINE/ON-LINE switch must be rotated to the OFF-LINE, POINT STEP or WORD STEP position. The INPUT SWITCHES are used to enter the data in the same format (operation or function) as described in Section 3, PROGRAMMING. The information entered with the switches will be displayed on the INPUT INDICATORS. In the point step mode, the D48 plots one point position for each POINT STEP switch depression until the operation or function is completed. In the word step mode, each WORD STEP switch depression plots all the point positions (or elements) required to complete the selected operation or function.

The following procedures describe the different manual operating modes of the D48.

OFF-LINE, WORD STEP Mode:

1. Rotate the ON-LINE/OFF-LINE switch to the OFF-LINE, WORD STEP position.

2. Enter the formatted information into the input register by depressing the corresponding INPUT SWITCHES. The input register is displayed on the INPUT INDICATORS.

3. Depress the WORD STEP switch. The D48 starts processing the information, and the ACTIVE indicator illuminates. When the WORD READY indicator illuminates and the input register clears, the specified function is completed. To continue, repeat Steps 2 and 3.

OFF-LINE, POINT STEP Mode:

1. Rotate the ON-LINE/OFF-LINE switch to the POINT STEP position.

2. Enter the formatted information into the input register by depressing the corresponding INPUT SWITCHES. The input register is displayed on the INPUT INDICATORS.

3. Depress the WORD STEP switch. If the information specifies functions other than point plotting, the execution is the same as when operating in the WORD STEP mode. If the information specifies point plotting, the POINT READY indicator illuminates.

4. Depress the POINT STEP switch. Each switch depression allows one point to be plotted. The POINT READY indicator extinguishes and the WORD READY indicator illuminates when all the points are plotted for the specified function. To continue, repeat Steps 2, 3, and 4.

ON-LINE, WORD STEP Mode

When operating in the ON-LINE/RUN mode, the D48 operation can be halted after each function is completed by rotating the ON-LINE/OFF-LINE switch to the ON-LINE, WORD STEP position. The WORD READY indicator illuminates when the computer transfers information to the D48. The function to be executed will be displayed on the INPUT INDICATORS. Depressing the WORD STEP switch clears the WORD READY indicator and starts the processing operation.

The D48 can be returned to the computer controlled condition when operating in any one of the manual modes by:

1. rotating the OFF-LINE/ON-LINE switch to the ON-LINE, RUN position, and

2. pressing the RESET switch.

2.2.10 35mm to 16mm Camera Conversion Procedure

The construction of the D48 camera allows for 16mm and 35mm movements and drive sprocket assemblies to be used interchangeably within the same camera transport. The 16mm film magazine requires an adapter for mounting on the film transport; however, a special 35mm magazine may be modified to accept 16mm film.

The procedure for converting from one film size to another is as follows (refer to Figure 2-5):

1. Place the motor FWD/OFF/REV switch in the OFF position.

* *

CAUTION

Failure to put the motor switch in the OFF position may cause injury to personnel or damage to equipment.

* *

2. Release movement latches.

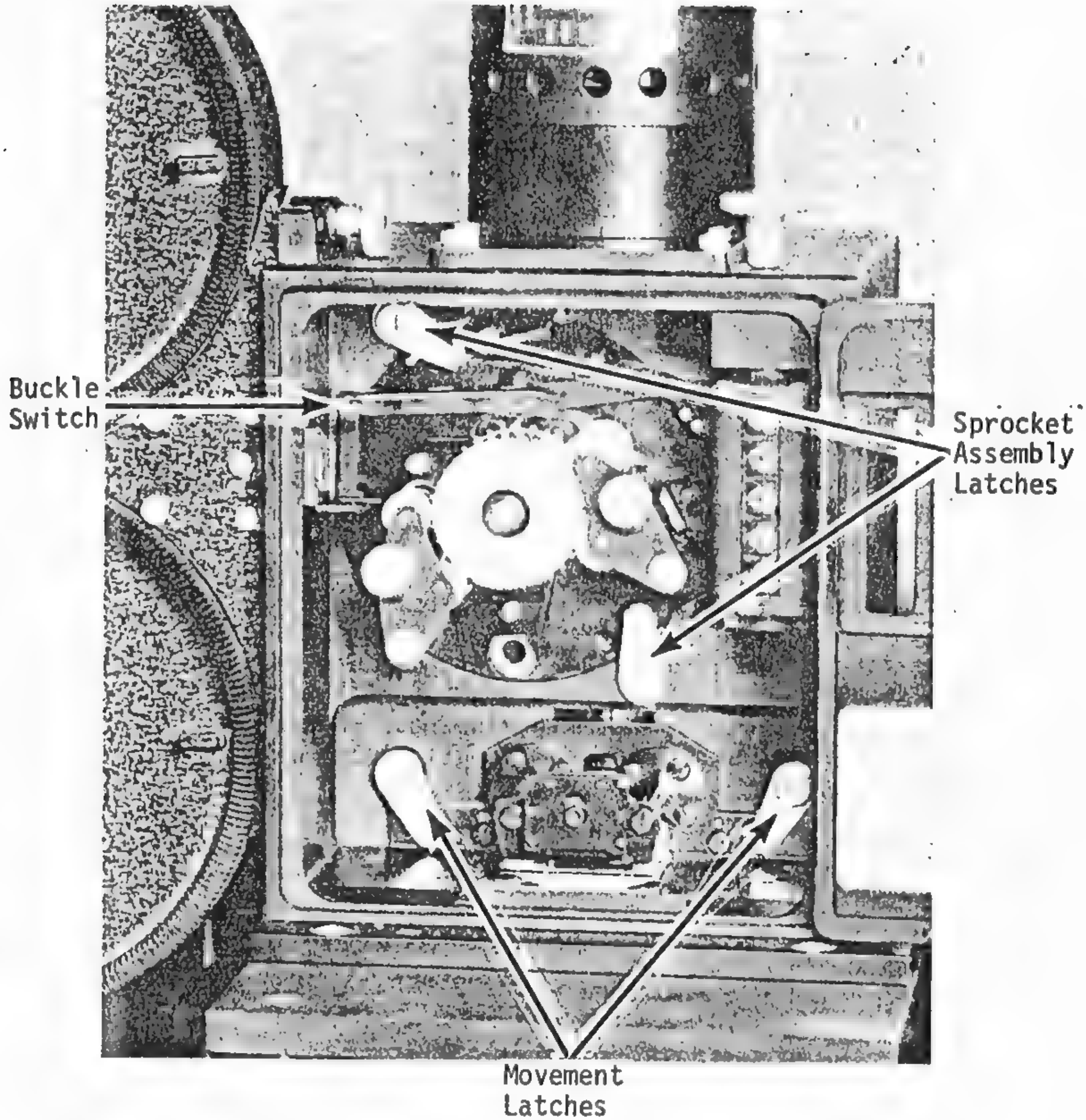


Figure 2-5. Camera 35mm and 16mm Conversion

3. Slide movement out of camera case and store in dust-free environment.

4. Pull out buckle switch.

5. Release sprocket assembly latches.

6. Pull sprocket assembly from camera and store in dust-free environment.

7. Install proper sprocket assembly.

8. Engage latches.

9. Push in buckle switch to correct position.

10. Install proper movement.

    NOTE: The operator may rotate the motor knob to assist in movement alignment.

11. Engage movement latches.

SECTION 3

PROGRAMMING

3.1 SCOPE

This section explains the programming characteristics of the D48 describing the word formats required when communicating with a computer.

3.2 PROGRAMMING CHARACTERISTICS

Programming the D48 requires familiarity with the functional characteristics (described in Section 1), operational characteristics (described in Section 2), and the word formats described in Paragraphs 3.3 and 3.4 of this section.

The D48 has an output interface (to the computer) and an input interface (from the computer). Each interface can transfer 16 bits of parallel information corresponding to the word formats. Actual word transfers are controlled by the D48 interface and the interface of the connected computer.

The output interface can only transfer output words to the computer in one format. The words contain status information on the operating conditions of the D48. The status word is only transmitted after receiving a request from the computer on the input channel. The significance of each bit within the status word is described in Paragraph 3.3.

The input interface receives several different 16-bit word formats that are required for:

...processing elements,
...plotting vectors,
...plotting points, or
...positioning the CRT (cathode ray tube) beam.

The formats are described in Paragraph 3.4.

Programming guidelines are furnished in Paragraph 3.5 as reminders that will help to eliminate common errors when programming the D48.

3.3 OUTPUT WORD FORMAT

Output words are transmitted from the D48 via the output channel in 16-bit format. Only one word format is required since only status information can be sent to the computer. Each status bit when a logical "1" represents a fault condition, a disable condition, or an operator request from the D48. The output status word format with bit assignments is illustrated in Figure 3-1. The function of each bit is explained in Table 3-1.

The D48 transmits the status word only when requested from the computer. The computer can request the status word by:

1. sending an Encoded Command Select (ECS) operation code (refer to Paragraph 3.4.1.1) specifying the Transfer Status Word command code (00110 binary), or
2. sending a Function Element Select (FES) operation code with Bit 12 of Word 1 set (refer to Paragraph 3.4.1.2). The status word is sent following the satisfactory completion of FES operation.

The status bits are reset following any one of the three actions listed below, except where noted in Table 3-1.

1. Processing of an Initial Condition Select operation (code 100 binary) with the Reset field (Bit 12) set (refer to Paragraph 3.4.1.5).
2. Depressing the RESET switch on the operator panel.
3. Transferring the output status word to the computer.

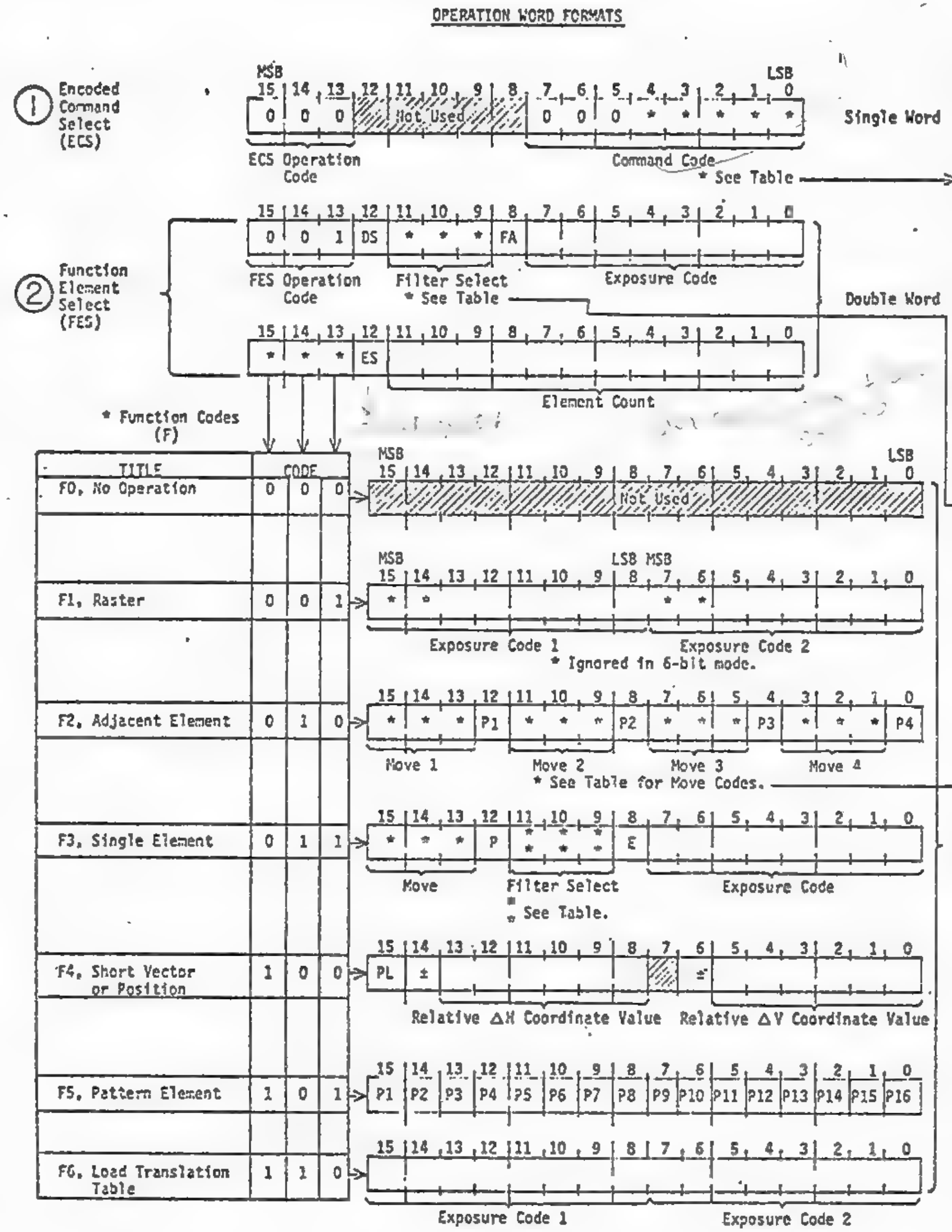
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Not Used	Not Used	Film End	Operator Request	P Zero D Detect	H Arith Fault	V Arith Fault	Point and Element Fault	Grid Timing Fault	Protect Fault	Voltage Fault	H V Disable	Filter Disable	Magazine Disable	Film Buckle Fault (except 70mm)	Servo Fault

Figure 3-1. Output Status Word Format

BIT POSITION	TITLE	FUNCTION
0	Servo Fault	The bit sets when the filter wheel does not rotate following a Filter Select command. Normally requires immediate attention by maintenance personnel before proceeding.
1	Film Buckle Fault	The bit sets when the film passing through the film transport starts buckling (or gathering) instead of winding up on the film reel. Normally requires immediate attention by the operator before proceeding.
2	Magazine Disable	The bit sets when the MAGAZINE DISABLE switch/indicator is depressed, illuminating the indicator. Film will not be advanced.
3	Filter Disable	The bit sets when the FILTER DISABLE switch/indicator is depressed, illuminating the indicator. Filter will not be selected.
4	H V Disable	The bit sets when the H.V. DISABLE switch/indicator is illuminated. The indicator is illuminated when high voltage is removed from the CRT (cathode ray tube) manually by: the H.V. DISABLE switch, or the HIGH VOLTAGE switch on the power panel, or due to some abnormal condition in the D48.
5	Voltage Fault	The bit sets when any one of several operating voltages fails. Normally requires immediate attention by maintenance personnel before proceeding.
6	Protect Fault	The bit sets when a failure occurs in the deflection circuitry. Normally requires immediate attention by maintenance personnel before proceeding.
7	Grid Timing Fault	The bit sets when a logic failure occurs that lengthens the control grid conduction time for the CRT beyond the recommended operating limits. Normally requires immediate attention by maintenance personnel before proceeding.
8	Point and Element Fault	The bit sets when either of the following conditions exist: 1. the point spacing within an element, as specified in Word 1 and/or Word 2 of the Point Element Select operation (refer to Paragraph 3.4.1.6), is less than one normal point spacing on the 4096 x 4096 array, or 2. the element spacing, as specified in Word 1 and/or Word 2 of the Point Element Select operation is less than the specified number of points per element (Word 3).
9	V Arithmetic Fault	The bit sets when any programmed operation causes the vertical deflection counters to overflow (wrap around).
10	H Arithmetic Fault	The bit sets when any programmed operation causes the horizontal deflection counters to overflow (wrap around).
11	P Zero Detect	The bit sets when function codes, Adjacent Element, Single Element and Pattern Element (refer to Paragraphs 3.4.2.3, 3.4.2.4 and 3.4.2.6, respectively), are interpreted with the P field bits equal to a logical "0" (reset). It should be noted that the P Zero Detect bit resets whenever the next P field bit equals a logical "1". This bit is a useful aid in program debugging and diagnostic troubleshooting.
12	Operator Request	This bit sets when depressing the illuminated REQUEST switch/indicator. The indicator is illuminated by sending an Illuminate Request Indicator command code from the computer.
13	Film End	The bit sets when the roll film magazine has run out of film.
14	Not Used	This bit is always a logical "0".
15	Not Used	This bit is always a logical "0".

Table 3-1. Status Bit Functions

OPERATION WORD FORMATS



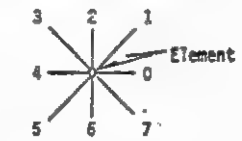
COMMAND CODES

CODE					TITLE
4	3	2	1	0	
0	0	0	0	0	No Operation
0	0	0	0	1	Illuminate ATTN Indicator
0	0	0	1	0	Extinguish ATTN Indicator
0	0	0	1	1	Illuminate REQUEST Indicator
0	0	1	0	0	Initiate Prime Mode
0	0	1	0	1	Initiate Test Mode
0	0	1	1	0	Transfer Status Mode
0	0	1	1	1	Advance Film
0	1	0	0	0	Filter Unchanged
0	1	0	0	1	Select Red Filter
0	1	0	1	0	Select Green Filter
0	1	0	1	1	Select Yellow Filter
0	1	1	0	0	Select Blue Filter
0	1	1	0	1	Select Magenta Filter
0	1	1	1	0	Select Cyan Filter
0	1	1	1	1	Select Neutral Filter
1	0	0	0	0	Area Exposure
1	0	0	0	1	Line Exposure
1	0	0	1	0	Color Exposure
1	0	0	1	1	Black and White Exposure
1	0	1	0	0	Bypass Translation
1	0	1	0	1	B&W Translation
1	0	1	1	0	Color Translation

FILTER SELECT CODES

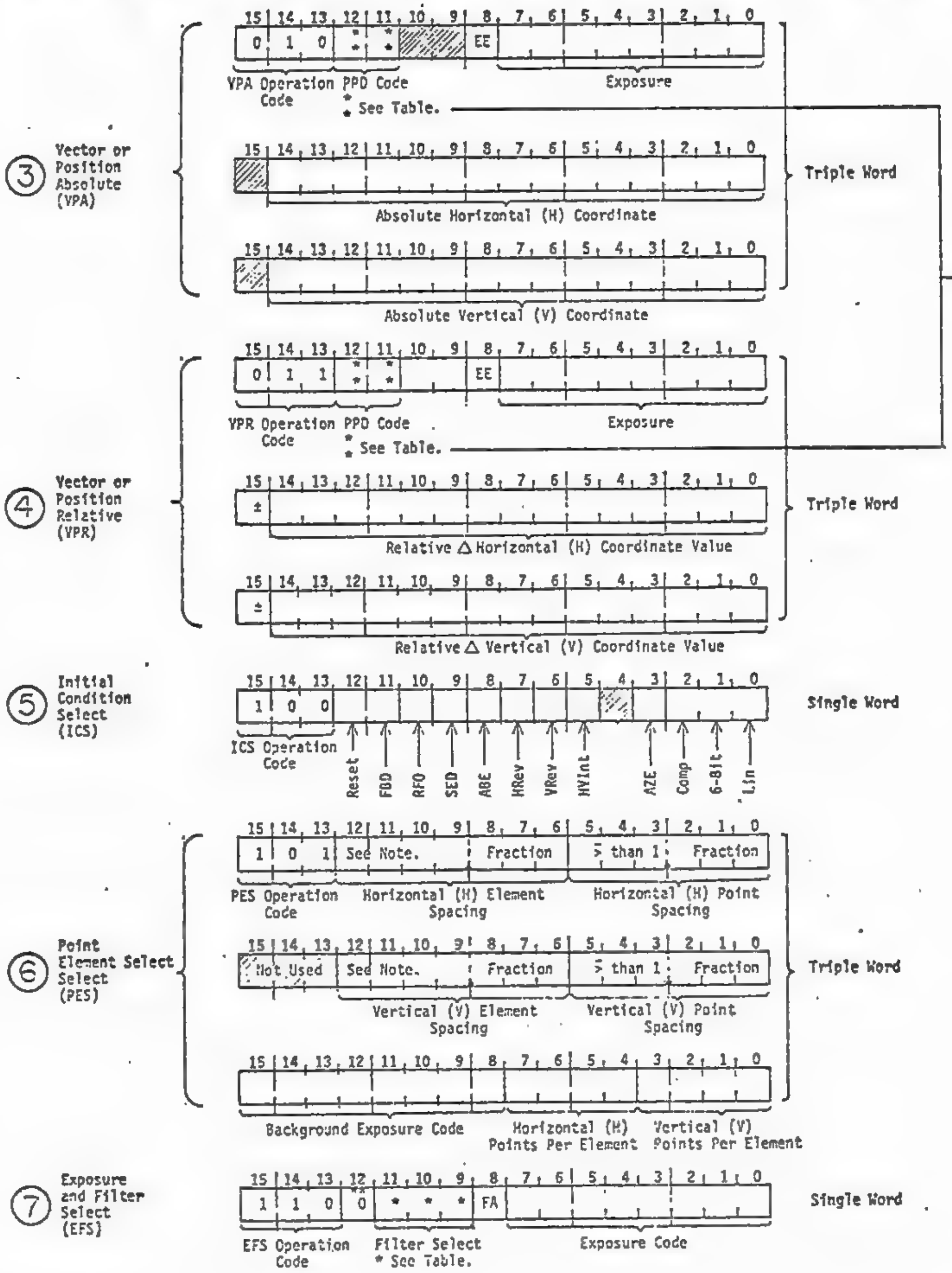
CODE			SELECTED FILTER
11	10	9	
0	0	0	No Change
0	0	1	Red
0	1	0	Green
0	1	1	Yellow
1	0	0	Blue
1	0	1	Magenta
1	1	0	Cyan
1	1	1	Neutral

MOVE DIRECTIONS



MOVE CODES

Code (Binary)			Direction (See Above)
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7


③ Vector or Position Absolute (VPA)
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
0 1 0 * * EE
VPA Operation Code
PPD Code * See Table.
Exposure
Absolute Horizontal (H) Coordinate
Absolute Vertical (V) Coordinate
Triple Word
④ Vector or Position Relative (VPR)
0 1 1 * * EE
VPR Operation Code
PPD Code * See Table.
Exposure
±
Relative △ Horizontal (H) Coordinate Value
±
Relative △ Vertical (V) Coordinate Value
Triple Word
⑤ Initial Condition Select (ICS)
1 0 0
ICS Operation Code
Reset
FBD
RFO
SED
ABE
HRev
VRev
HVInt
AZE
Comp
6-Bit
Lin
Single Word
⑥ Point Element Select (PES)
1 0 1 See Note. Fraction ≥ than 1 Fraction
PES Operation Code
Horizontal (H) Element Spacing
Horizontal (H) Point Spacing
Not Used See Note. Fraction ≥ than 1 Fraction
Vertical (V) Element Spacing
Vertical (V) Point Spacing
Background Exposure Code
Horizontal (H) Points Per Element
Vertical (V) Points Per Element
Triple Word
⑦ Exposure and Filter Select (EFS)
1 1 0 ** 0 * * * FA
EFS Operation Code
Filter Select * See Table.
Exposure Code
Single Word

PPD CODE

CODE 12 11	FUNCTION
0 0	Position CRT Beam
0 1	Position CRT Beam and Plot Point
1 0	Plot Vector Line
1 1	Not Used

NOTE: *The (H) element spacing must be greater than or equal to the number of (H) points per element. The (V) element spacing must be greater than or equal to the number of (V) points per element.*

** Must always be a logical "0".

Figure 3-2. Input Word Format Summary

3.4 INPUT WORD FORMAT

Two classifications of formatted 16-bit input words (operation and function) can be received from the computer via the input channel. A summary of the word formats is illustrated in Figure 3-2.

The operation input words (described in Paragraph 3.4.1) condition the D48 to:

1. plot raster picutres,
2. plot vectors,
3. plot points,
4. position the CRT (cathode ray tube) beam on the basic 4096 x 4096 point array, or
5. accept information from the computer in the function word format.

The function input words (described in Paragraph 3.4.2) provide the additional information required to satisfactorily complete the Function Element Select (FES) operation. This additional information, including commands, parameters, and special features, is uniquely formatted to reduce the number of input words required from the computer when processing elements, short vectors, or repositioning the CRT beam within a short distance.

The D48 automatically accepts and interprets the first word transfer from the computer following:

1. the initial application of A.C. input power,
2. the depressing of the RESET switch, or
3. the satisfactory execution of a previous operation code,

as Word 1 of an operation input word.

3.4.1 Operation Word Formats

The formats for operation input words are separated into seven operations selected by a three-bit operation code. The operations, codes, and number of input words required from the computer are listed in Table 3-2.

The operation word format consists of up to three 16-bit words (single word, double word, or triple word) from the computer (refer to Figure 3-2). The three most significant bits (MSB) of Word 1 (Bits 13, 14, and 15) contain the operation code. The remaining bits in the word (or words) specify commands, parameters or selected features that are described for each operation in Paragraphs 3.4.1.1 through 3.4.1.7.

Additional input words, function formatted, are ONLY required for completing the Function Element Select (FES) operation described in Paragraph 3.4.1.2.

Word 1 Bits

CODE (BINARY) 15	14	13	OPERATION	REQUIRED INPUT WORDS (16-BIT)
0	0	0	Encoded Command Select (ECS)	1
0	0	1	Function Element Select (FES)	2*
0	1	0	Vector or Position Absolute (VPA)	3
0	1	1	Vector or Position Relative (VPR)	3
1	0	0	Initial Condition Select (ICS)	1
1	0	1	Point Element Select (PES)	3
1	1	0	Exposure and Filter Select (EFS)	1

*Requires additional input words (function formatted) to complete the operation.

Table 3-2. Operation Codes

3.4.1.1 Encoded Command Select (ECS)

The ECS operation (operation code, 000 binary) transmits one of 20 command codes to the D48. The command codes listed and described in Table 3-3 are used to select special features or operating conditions in the D48 not normally selectable in other operation word formats. The exceptions are Filter Select, Film Advance, and Transfer Status Word which may be selected with one or more of the other operation codes.

The ECS operation requires only one 16-bit input word (single word format) from the computer which is illustrated in Figure 3-3.

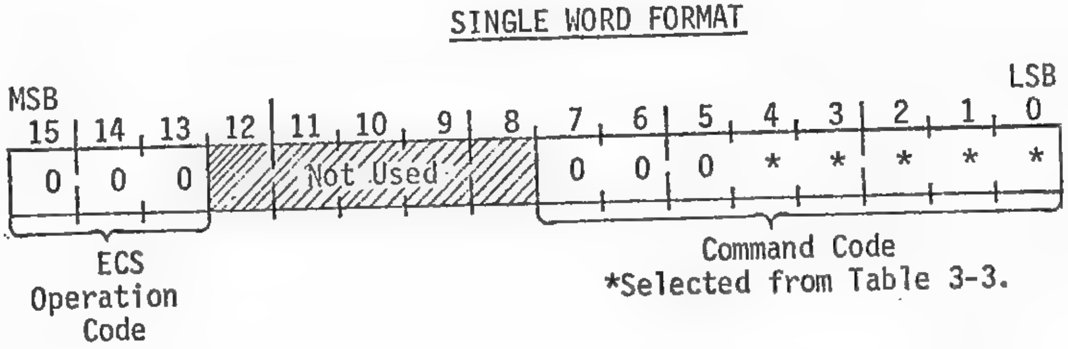


Figure 3-3. Encoded Command Select (ECS) Word Format

	CODE (BINARY)						
Bit Position	4	3	2	1	0	TITLE	FUNCTION
	0	0	0	0	0	No Operation	The initial conditions of the D48 remain the same. Used in programming to allow for modifications.
	0	0	0	0	1	Illuminate ATTN Indicator	Illuminates the ATTN (Attention) indicator on the control panel. This command is normally used to signal the operator that a condition exists within the D48 that requires attention.
	0	0	0	1	0	Extinguish ATTN Indicator	Extinguishes the ATTN (Attention) indicator on the control panel.
	0	0	0	1	1	Illuminate REQUEST Indicator	Illuminates the REQUEST switch/indicator on the control panel which enables the switch. When depressed, the switch sets the request bit in the output status word.
	0	0	1	0	0	Initiate Prime Mode	Initiates the prime mode. The prime mode consists of plotting all points on the basic 4096 x 4096 array at a constant (maximum) exposure level.
	0	0	1	0	1	Initiate Test Mode	Initiates the generation of the test pattern. The test pattern is illustrated in Figure 2-2.
	0	0	1	1	0	Transfer Status Word	Transfers a 16-bit output word, containing status information, to the computer on the output interface.
	0	0	1	1	1	Film Advance	Causes the film transport to advance the film one frame.
	0	1	0	0	0	Filter Unchanged	The color filter remains unchanged. Used in programming to allow for modifications.
	0	1	0	0	1	Select Red Filter	Positions the red filter in the optics path.
	0	1	0	1	0	Select Green Filter	Positions the green filter in the optics path.
	0	1	0	1	1	Select Yellow Filter	Positions the yellow filter in the optics path.
	0	1	1	0	0	Select Blue Filter	Positions the blue filter in the optics path.
	0	1	1	0	1	Select Magenta Filter	Positions the magenta filter in the optics path.
	0	1	1	1	0	Select Cyan Filter	Positions the cyan filter in the optics path.
	0	1	1	1	1	Select Neutral Filter	Positions the neutral filter in the optics path.
	1	0	0	0	0	Area Exposure	Selects the proper CRT beam light output for exposing a plotted area versus a plotted line.
	1	0	0	0	1	Line Exposure	Selects the proper CRT beam light output for exposing a plotted line versus a plotted area.
	1	0	0	1	0	Color Exposure	Selects the proper CRT beam light output for exposing color film versus black and white film.
	1	0	0	1	1	Black and White Exposure	Selects the proper CRT beam light output for exposing black and white film versus color film.
	1	0	1	0	0	Bypass Translation	Bypasses the exposure translation table.
	1	0	1	0	1	Black and White Translation	Uses the first 256 words of the translation table for any color filter.
	1	0	1	1	0	Color Translation	Uses the first 256 words of the translation table for all color filters except green and blue. Uses the second 256 words of the translation table for the green filter. Uses the third 256 words of the translation table for the blue filter.

NOTE: A logical "1" in any one of the Bits 5 through 7 of the command code field causes a No Operation command to be executed.

Table 3-3. Command Codes

The fields within the word are interpreted as follows:

Command Code field: (Bits 0 through 7)	Selects the command code listed in Table 3-3. It should be noted that only Bits 0 through 4 are variable, and Bits 5 through 7 must be logical "0". A logical "1" in any one of the bit positions 5 through 7 is interpreted as a No Operation command.
ECS Operation Code field: (Bits 13, 14, and 15)	Selects the operation code which is a 000 (binary) for an ECS operation.

After executing the ECS operation, the D48 automatically interprets the next 16-bit input word from the computer as an operation formatted word.

3.4.1.2 Function Element Select (FES)

The FES operation (operation code, 001 binary) initiates the process of plotting elements or short vectors. The double word format operation (requiring two 16-bit input words from the computer) permits the selection of:

...an output status word transfer,
...a color filter,
...a film advance,
...an element exposure code,
...a function code,
...a data source for plotting elements, and
...the number of elements or short vectors plotted with this operation code.

If additional operating features, commands, or parameters are required for plotting elements or short vectors, one or more of the other operation codes will have to be executed first. The word transfers from the computer following Word 2 of the FES operation are interpreted in one of the function word formats (refer to Paragraph 3.4.2) as specified by the function code in Bits 13, 14, and 15 of Word 2. The D48 will continue interpreting the input words in the function format until the element count is completed (decremented to zero).

> NOTE: *Once the D48 starts to execute an FES operation and begins to process the function input words, the ONLY exit back to interpreting another operation input word is to complete (satisfy) the element count.*

The FES word format is illustrated in Figure 3-4.

DOUBLE WORD FORMAT

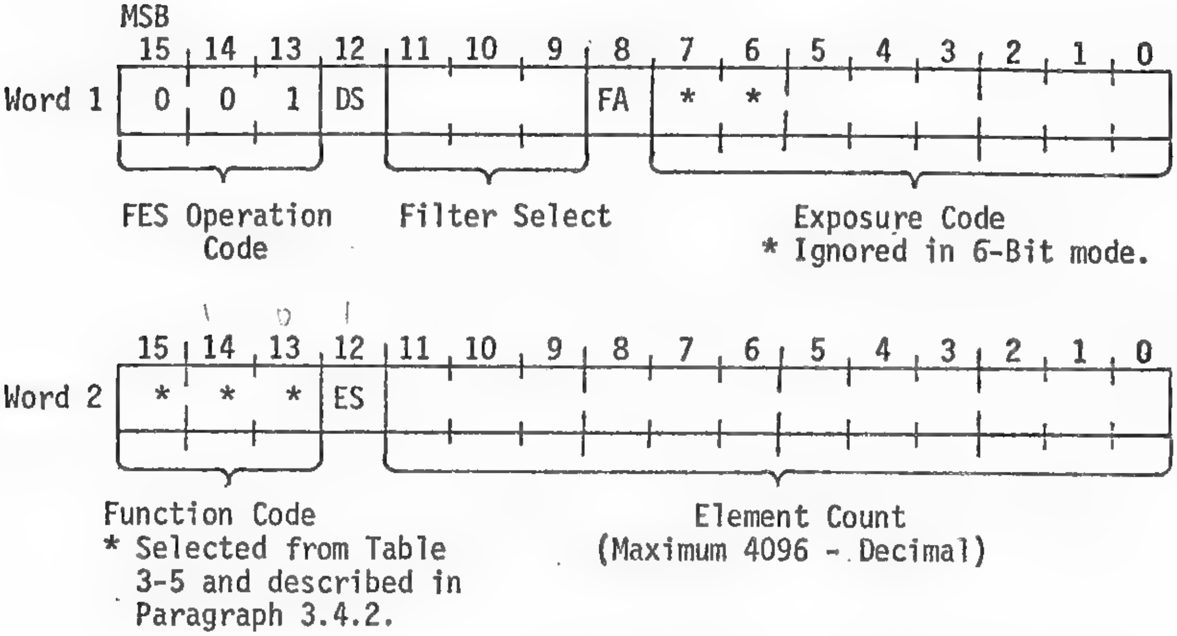


Figure 3-4. Function Element Select (FES) Word Format

The fields in both words are interpreted as follows:

Exposure Code field: (Bits 0 through 7 of Word 1)	Selects one of 256 (decimal) film exposure codes representing exposure levels in 8-bit mode. In 6-bit mode, Bits 6 and 7 are ignored, limiting the selection to one of 64 (decimal) levels. Bit 0 is the least significant bit (LSB) for both modes.
FA (Film Advance) field: (Bit 8 of Word 1)	Advances the film one frame when a logical "1". If an automatic film transport is not being used or if the MAGAZINE DISABLE switch/indicator on the test and calibration panel has been depressed, illuminating the indicator, this FA bit will be ignored.
Filter Select field: (Bits 9, 10, and 11)	Selects one of the color filters according to the three-bit code listed in Table 3-4.

	CODE (BINARY)			
Bits	11	10	9	SELECTED COLOR FILTER
	0	0	0	No change
	0	0	1	Red
	0	1	0	Green
	0	1	1	Yellow
	1	0	0	Blue
	1	0	1	Magenta
	1	1	0	Cyan
	1	1	1	Neutral

Table 3-4. Filter Select Codes

If the FILTER DISABLE switch/indicator has been depressed, illuminating the indicator, the Filter Select field will be ignored.

DS (Deferred Status) field: (Bit 12 of Word 1)	Initiates the transfer of an output status word to the computer when a logical "1" following the completion of the FES operation (all elements specified in the Element Count field plotted). The output status word format is described in Paragraph 3.3. If an output status word is required before starting an operation, execute the ECS operation code (000) and specify the transfer status word command code (00110 binary).
FES Operation Code field: (Bits 13, 14, and 15 of Word 1)	Selects the operation code which is a 001 (binary) for a FES operation.
Element Count field: (Bits 0 through 11 of Word 2)	Selects the number of elements or short vectors that are to be processed by this operation code. Each element or vector is plotted from the information provided in the following function formatted input words from the computer. It should be noted that each input word may specify one or more elements or vectors, depending upon the function code selected in Bits 13, 14, and 15 (refer to Paragraph 3.4.2). After plotting the specified number of elements or vectors, the D48 automatically interprets the next input word as an operation formatted word.

It should be noted that an Element Count field of all logical "0"s will cause the processing of 4096 elements or short vectors.

ES (Element Source) field: (Bit 12 of Word 2)	When a logical "0", selects the next single 16-bit input word from the computer as the only source of information for plotting all the elements or short vectors specified by the Element Count field. When a logical "1", selects consecutive 16-bit input words from the computer until the number of elements or vectors as specified by the Element Count field are plotted.
Function field: (Bits 13, 14, and 15)	Selects one of the seven function input word formats, according to the three-bit code in Table 3-5, for plotting elements or short vectors.

	CODE (BINARY)			FUNCTION
Bits	15	14	13	
	0	0	0	No Operation
	0	0	1	Raster
	0	1	0	Adjacent Element
	0	1	1	Single Element
	1	0	0	Short Vector or Position
	1	0	1	Pattern Element
	1	1	0	Load Translation Table

Table 3-5. Function Codes

The function code selected determines the format interpretation of the following data words from the computer. Each function code is described in Paragraphs 3.4.2.1 through 3.4.2.7, including illustrations showing the required word formats. The D48 will continue to interpret the input words in the selected function word format until the required number of elements or short vectors as specified by the Element Count field are processed. The next computer input word will then be interpreted as an operation formatted word.

3.4.1.3 Vector or Position Absolute (VPA)

The VPA operation (operation code, 010 binary) initiates the process of plotting a point, plotting a vector, or positioning the CRT (cathode ray tube) beam. The triple word format operation (requiring three 16-bit input words from the computer) permits the selection of horizontal and vertical coordinates for determining the destination position of the CRT beam.

The logical state of two bits (PPD code) determines if a vector line is plotted, if a point is plotted after repositioning the CRT beam, or if the beam is just repositioned.

The VPA word format is illustrated in Figure 3-5 with each field described in the paragraphs following the figure.

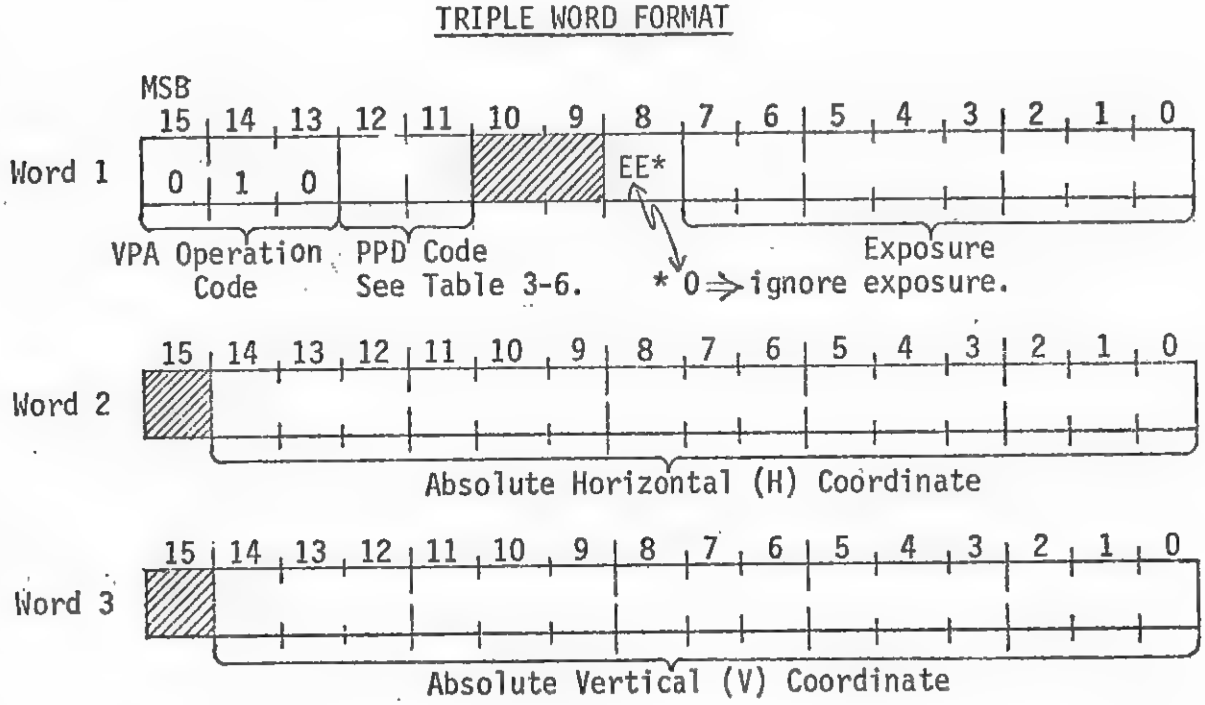


Figure 3-5. Vector or Position Absolute (VPA) Word Format

Absolute Horizontal (H) Coordinate field: (Bits 0 through 14 of Word 2)	Specifies the horizontal coordinate for defining the destination position of the CRT beam, a plotted vector line, or a plotted point.
Absolute Vertical (V) Coordinate field: (Bits 0 through 14 of Word 3)	Specifies the vertical coordinate for defining the destination position of the CRT beam, a plotted vector line, or a plotted point.

Exposure Code field (Bits 0 through 7 in Word 1)	Selects one of 256 (decimal) exposure codes representing exposure levels in 8-bit mode. In 6-bit mode, Bits 6 and 7 are ignored, limiting the selection to one of 64 (decimal) levels. Bit 0 is the least significant bit (LSB) for both modes.
Enable Exposure field (Bit 8)	The exposure code is ignored when a logical "0". The exposure code is used when a logical "1".
PPD (Plot or Position Designator) Code field: (Bits 11 and 12 of Word 1)	The specific function performed when executing a VPA operation is determined by the plot or position designator code listed in Table 3-6.

	CODE (BINARY)		FUNCTION
Bits	8	9	
	0	0	Positions the CRT beam to the destination position specified by the Absolute Horizontal and Vertical Coordinate fields (without plotting a point or a vector line).
	0	1	Positions the CRT beam to the destination position specified by the Absolute Coordinate fields and plots a point at the destination position (without drawing a vector line).
	1	0	Plots a vector line between the current CRT beam position and the destination position specified by the Absolute Coordinate fields.
	1	1	Not used.

Table 3-6. VPA Plot or Position Designator Codes

VPA Operation Code field: (Bits 13, 14, and 15 of Word 1)	Selects the operation code which is a 010 (binary) for a VPA operation.

If additional operating features, commands, or parameters are required for plotting vectors or points (such as selecting color filters or exposure levels, etc.), one or more of the other operation codes will have to be executed first.

After executing the VPA operation, the D48 automatically interprets the next input word from the computer as an operation formatted word.

3.4.1.4 Vector or Position Relative (VPR)

The VPR operation (operation code, 011 binary) initiates the process of plotting a point, plotting a vector, or positioning the CRT (cathode ray tube) beam. The triple word format operation (requiring three 16-bit input words from the computer) permits the selection of:

1. The new horizontal and vertical CRT beam coordinate position values which are relative to the current beam position coordinates.
2. The adding or subtracting of the values in Step 1 to the current CRT beam position coordinates.
3. The selecting of a plot or position designator (PPD) code (refer to Table 3-7).

	CODE (BINARY)		FUNCTION
Bits	8	9	
	0	0	Positions the CRT beam to the resultant destination position specified by the Relative Horizontal and Vertical Coordinate Value fields (without plotting a point or a vector line).
	0	1	Positions the CRT beam to the resultant destination position specified by the Relative Coordinate Value fields, and plots a point at the destination position (without drawing a vector line).
	1	0	Plots a vector line between the current CRT beam position and the resultant destination position specified by the Relative Coordinate Value fields.
	1	1	Not used.

Table 3-7. VPR Plot or Position Designator Codes

The VPR word format is illustrated in Figure 3-6 with each field described in the paragraphs following.

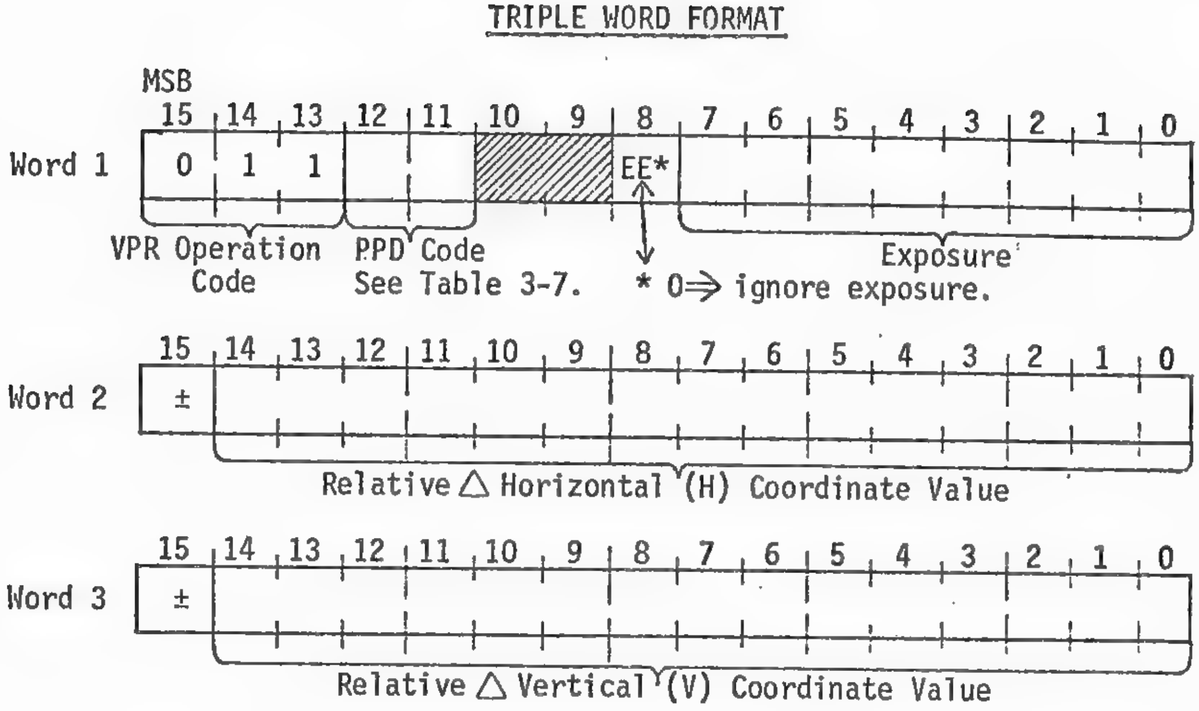


Figure 3-6. Vector or Position Relative (VPR) Word Format

Relative △ Horizontal (H) Coordinate Value field: (Bits 0 through 14 in Word 2)	Specifies the position value (number of points in the basic 32,768 x 32,768 array) that may be added or subtracted to the current horizontal CRT beam coordinate to arrive at a horizontal destination coordinate for plotting a vector, plotting a point, and/or positioning the beam.
Relative △ Vertical (V) Coordinate Value field: (Bits 0 through 14 in Word 3)	Specifies the position value that may be added or subtracted to the current vertical CRT beam coordinate to arrive at a vertical destination coordinate for plotting a vector, plotting a point, and/or positioning the beam.
Enable Exposure field: (Bit 8)	The exposure code is ignored when a logical "0". The exposure code is used when a logical "1".
PPD (Plot or Position Designator) Code field: (Bits 11 and 12 of Word 1)	The specific function performed when executing a VPR operation is determined by the plot or position designator code listed in Table 3-7.

± field: (Bit 15 in both Word 2 and Word 3)	When a logical "0", the coordinate position value is added to the respective current CRT beam coordinate position. When a logical "1", the coordinate position value is subtracted from the respective current beam coordinate position.
VPR (Vector or Position Relative) Operation Code field:	Selects the operation code which is a 011 (binary) for a VPR operation.

If additional operating features, commands, or parameters are required for plotting vectors or points (such as selecting color filters, exposure levels, etc.), one or more of the other operation codes will have to be executed first.

After executing the VPR operation, the D48 automatically interprets the next input word from the computer as an operation formatted word.

3.4.1.5 Initial Condition Select (ICS)

The ICS operation (operation code, 100 binary) selects certain operating conditions or special features of the D48 that are not selectable with the other operation codes. The operation requires only one 16-bit input word (single word format) from the computer which is illustrated in Figure 3-7. Each bit (field) in the ICS operation selects a special operating condition as described in Table 3-8. It should be noted that if the Reset field (Bit 12) is a logical "1", all other bits (0 through 11) are interpreted as logical "0"s. In addition, the Reset bit causes the following changes in the D48 control logic:

1. The horizontal and vertical positioning registers are reset to "0"s, positioning the CRT (cathode ray tube) beam in the lower left-hand corner of the film image area.
2. All output status bits to the computer are reset to "0"s.
3. The ATTN indicator, if illuminated, will be extinguished.
4. The point and element spacing will be set to the normal configuration in the 4096 x 4096 array with each element interpreted as a single point.

After executing the single word instruction, the D48 automatically interprets the next input word from the computer as an operation formatted word.

BIT	TITLE	LOGICAL STATE	OPERATING CONDITION SELECTED
0	LIN (Linear)	"0"	The exposure level on film is proportional to the logarithm of the exposure code value.
		"1"	The exposure level on film is directly proportional to the exposure code value.
1	6-Bit	"0"	The exposure code field in the operation and function formatted input words are interpreted in an eight-bit format (one of 256 exposure levels).
		"1"	The exposure code field in the operation and function formatted input words are interpreted in a six-bit format (one of 64 exposure levels).
2	COMP (Complement)	"0"	The exposure codes are interpreted so that an increase in the exposure values results in an increase in the exposure level on film.
		"1"	The exposure codes are interpreted so that an increase in the exposure values results in a decrease in the exposure level on film.
3	AZE (Allow Zero Exposure)	"0"	A zero exposure code results in no exposure of the film unless the ABE field (Bit 8) is a logical "1" (refer to Bit 8 in this table).
		"1"	A zero exposure code results in exposure of the film equal to the film fog level unless modified by a logical "1" in the ABE field (Bit 8).
4	Not Used		
5	H V Int (Horizontal and Vertical Axis Interchanged)	"0"	Selects the normal horizontal (left and right) and vertical (bottom and top) axis on film (refer to Figure 1-3).
		"1"	Interchanges the horizontal axis with the vertical axis.
6	V Rev (Vertical Reverse)	"0"	The deflection circuits move the CRT (cathode ray tube) beam on film in the normal vertical direction (bottom to top) as shown in Figure 1-3.
		"1"	The direction of the vertical deflection reverses (top to bottom).
7	H Rev (Horizontal Reverse)	"0"	The deflection circuits move the CRT beam in the normal horizontal direction (left to right) as shown in Figure 1-2.
		"1"	The direction of the horizontal deflection reverses (right to left).
8	ABE (Allow Background Exposure)	"0"	The zero exposure codes are interpreted according to the logical state of the AZE field (refer to Bit 3 in this table).
		"1"	The zero exposure codes expose the film at the level specified in the Background Exposure Code field in Word 3 of the Point Element Select operation (refer to Paragraph 3.4.1.6).
9	SED (Short End of Line Delay)	"0"	Selects the normal flyback delay (approximately 100 microseconds) to reposition the CRT beam at the beginning of a new horizontal line when plotting elements in the raster mode.
		"1"	Selects the short flyback delay (approximately 20 microseconds) to reposition the CRT beam at the beginning of a new horizontal line. The short delay is only recommended on short raster lines (approximately 100 point positions, or less, on the basic 4096 x 4096 array).
10	RFO (Reverse Field Order)	"0"	Selects the normal field order of executing function formatted input words as follows: FUNCTION — EXECUTION FIELD ORDER Raster (001) — Exposure 1, Exposure 2 Adjacent Element (010) — MOV 1, P1; MOV 2, P2; MOV 3, P3; MOV 4, P4 Pattern Element (101) — P1 ↓ P16
		"1"	Selects the reverse field order of executing function formatted input words as follows: FUNCTION — EXECUTION FIELD ORDER Raster (001) — Exposure 2, Exposure 1 Adjacent Element (010) — MOV 4, P4; MOV 3, P3; MOV 2, P2; MOV 1, P1 Pattern Element (101) — P16 ↓ P1
11	FBD (Flyback Disable)	"0"	Enables the CRT beam flyback when executing a F1, F2, F3, or F5 function and the number of elements processed equals the Element Count field in the Function Element Select operation.
		"1"	Disables the CRT beam flyback so that the next element continues to be plotted on the same line and adjacent to the last element.

Table 3-8. ICS Field Assignments

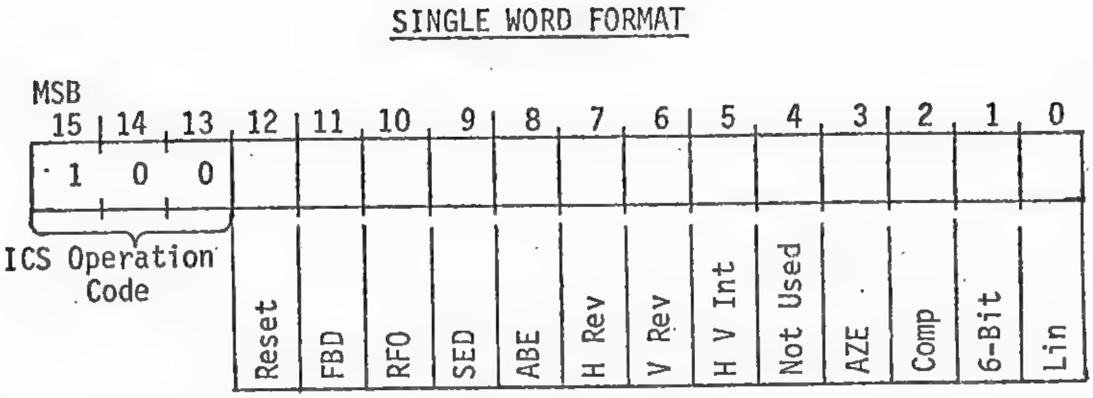


Figure 3-7. Initial Condition Select (ICS) Word Format

3.4.1.6 Point Element Select (PES)

The PES operation (operation code, 101 binary) selects the number of points and spacings required in creating elements. The triple word format (requiring three 16-bit input words from the computer) permits the selection of:

1. The horizontal and vertical spacing between points.
2. The horizontal and vertical spacing between elements.
3. The number of horizontal and vertical points per element.
4. The background exposure level executed when an exposure code of zero is received from the computer (provided that the ABE field, Bit 8, in the Initial Condition Select operation input word is a logical "1").

The PES word format is illustrated in Figure 3-8 with each field described in the paragraphs following the figure.

TRIPLE WORD FORMAT

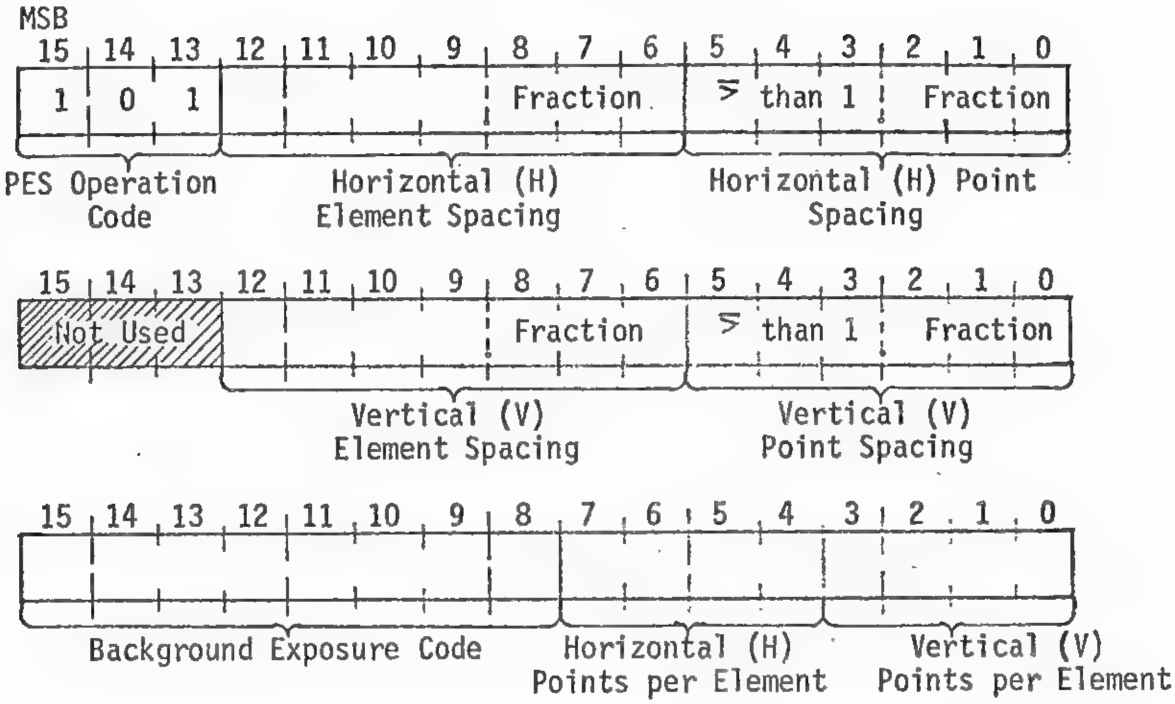


Figure 3-8. Point Element Select (PES) Word Format

Horizontal (H) and Vertical (V) Point Spacing fields: (Bits 0 through 5 in Words 1 and 2, respectively)	Specify the spacing (as a factor of the basic 4096 x 4096 point array) between points per element for both the horizontal and vertical axis. Bits 3 through 5 within each field designate the number of full basic point spacings; 1 through 7 (001 through 111 binary) and Bits 0 through 2 designate the fractions (in eighths) of a basic point spacing (000 through 111 binary). The range of point spacings can vary from a minimum of 001.000 (binary) to a maximum of 111.111 (binary).

NOTE: *The minimum spacing between points is one full basic point spacing to prevent overlapping of one point on another. If the Bits 3 through 5 are all logical "0"s (in Word 1 or Word 2), the less than one full point spacing is detected, resulting in the Point Element Fault field (Bit 8) setting in the output status word. Also, the CRT (cathode ray tube) beam will be disabled, preventing the film from being exposed.*

Horizontal (H) and Vertical (V) Points per Element fields: (Bits 4 through 7 and 0 through 3 in Word 3)	Specify the number of points (within the basic 4096 x 4096 point array) that are exposed in the horizontal and vertical directions for each element. The number of points selectable can vary from 1 to 16 (0001 through 1111 binary) in the H and V axis. It should be noted that a 0000 (binary) is interpreted to be 16.
Horizontal (H) and Vertical (V) Element Spacing fields: (Bits 6 through 12 in Word 1 and 2, respectively)	Specify the spacing (as a factor of the basic 4096 x 4096 point array) between elements for both the horizontal and vertical axis. Bits 9 through 12 within each field designate the number of full basic point spacings (1 through 15 decimal, 0001 through 1111 binary). Bits 6 through 8 designate the fractions (in eighths) of a basic point spacing (000 through 111 binary). The range of element spacings can vary from a minimum of 0001.000 (binary) to a maximum of 1111.111 (binary).
	NOTE: *The element spacing for each axis must always be equal to, or greater than, the selected number of points per element (Word 3, Bits 4 through 7 and 0 through 3, respectively), to prevent overlaying of one element on another. If an element overlaying condition exists, the Point Element Fault bit in the output status word sets, and the CRT beam is disabled, preventing the film from being exposed.*
Background Exposure field: (Bits 8 through 15 in Word 3)	Specifies the exposure level generated on film for zero exposure codes from the computer when the Allow Background Exposure (ABE) field (Bit 8), in the Initial Condition Select operation input word, is set to a logical "1". It should be noted that the ABE feature is normally used with the Pattern Element function (F5) for creating bi-level images.
PES Operation Code field: (Bits 13, 14, and 15 in Word 1)	Selects the operation code which is a 101 (binary) for a PES operation.

After executing the triple word instruction, the D48 automatically interprets the next input word from the computer as an operation formatted word.

3.4.1.7 Exposure and Filter Select (EFS)

The EFS operation (operation code, 110 binary) is normally used in conjunction with the VPA or VPR operations for plotting vectors or points. The single word format operation (requiring one 16-bit input word from the computer) permits the selection of:

...a film exposure level,
...a film advance, and
...a color filter.

The EFS word format is illustrated in Figure 3-9 with each field described in the paragraphs following the figure.

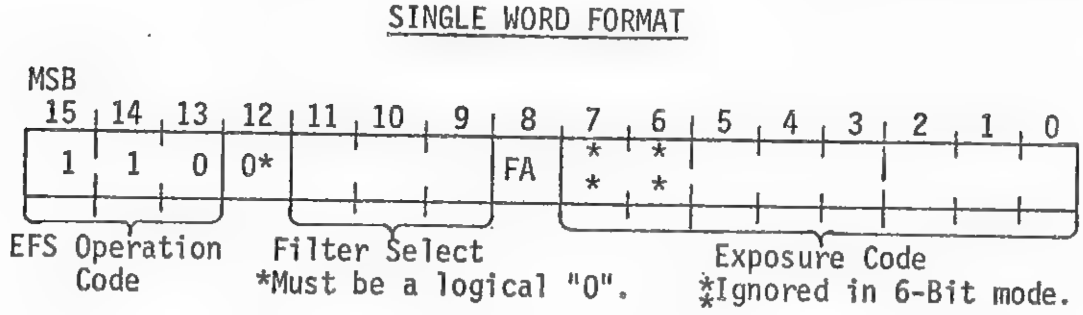


Figure 3-9. Exposure and Filter Select (EFS) Word Format

Exposure Code field: (Bits 0 through 7)	Specifies one of 256 (decimal film exposure codes representing exposure levels in 8-bit mode (one of 64 in 6-bit mode) that is required for plotting vectors.
EFS Operation Code field: (Bits 13, 14, and 15)	Selects the operation code which is a 110 (binary) for an EFS operation.
FA (Film Advance) field: (Bit 8)	Advances the film one frame when a logical "1". If an automatic film transport is not being used, or if the MAGAZINE DISABLE switch/indicator on the test and calibration panel has been depressed, illuminating the indicator, this FA bit will be ignored.
Filter Select field: (Bits 9 through 11)	Selects one of the color filters according to the 3-bit code listed in Table 3-9.

	CODE (BINARY)			
Bits	11	10	9	SELECTED COLOR FILTER
	0	0	0	No Change
	0	0	1	Red
	0	1	0	Green
	0	1	1	Yellow
	1	0	0	Blue
	1	0	1	Magenta
	1	1	0	Cyan
	1	1	1	Neutral

Table 3-9. Filter Select Codes

If the FILTER DISABLE switch/indicator has been depressed, illuminating the indicator, the Filter Select field will be ignored.

After executing the single word instruction, the D48 automatically interprets the next input word from the computer as an operation formatted word.

3.4.2. Function Word Formats

Function input words from the computer are formatted to provide the required information for completing a Function Element Select operation (refer to Paragraph 3.4.1.2). The word formats are separated into seven functions selected by a three-bit function code. The functions, codes, and number of elements plotted with each input word are listed in Table 3-10. All the function word formats are illustrated in Figure 3-2.

The function word format consists of a single 16-bit input word from the computer that follows Word 2 of the Function Element Select operation (operation code, 001 binary). Word 2 of the operation contains the function code field (Bits 13, 14, and 15) that selects a particular function word format. The D48 continues interpreting the function formatted words until the element count, also in Word 2, is completed (decremented to zero). The next input word from the computer will then be interpreted as an operation formatted word.

The function formatted words specify commands, parameters and/or selected features that are described for each function in Paragraphs 3.4.2.1 through 3.4.2.7.

FES Operation Word 2 Bits

CODE (BINARY)			FUNCTION	ELEMENTS PER INPUT WORD TRANSFER
15	14	13		
0	0	0	No Operation (No Op)	1
0	0	1	Raster	2
0	1	0	Adjacent Element	4
0	1	1	Single Element	1
1	0	0	Short Vector or Position	1*
1	0	1	Pattern Element	16
1	1	0	Load Translation Table	2

* Plots one vector line up to 63 points long on the basic 4096 x 4096 array.

Table 3-10. Function Codes

3.4.2.1 FO, No Operation

The FO function (function code, 000 binary) specifies a no operation condition to the D48. The function is used in programming to allow for modifications. Each 16-bit input word is interpreted as one element decrementing the element count, in Word 2 of the Function Element Select operation, by one. When the number of input words equals the element count field, the operation is completed. The next input word from the computer will be interpreted as an operation formatted word.

The function word format is illustrated in Figure 3-10.

MSB LSB

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Not Used															

Figure 3-10. FO Word Format

3.4.2.2 F1, Raster

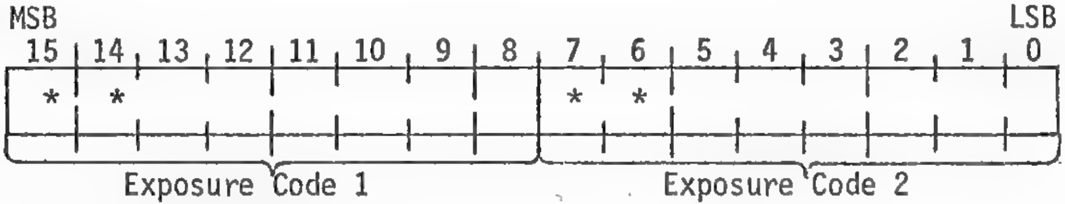
The F1 function (function code, 001 binary) specifies two exposure codes for plotting consecutive elements in raster mode. Each 16-bit input word is interpreted as two elements, decrementing the element count in Word 2 of the Function Element Select operation by two. When the number of elements in a horizontal line equals the Element Count field, the D48 initiates the end-of-line delay which causes:

1. the horizontal deflection to position the CRT (cathode ray tube) beam at the beginning of the next line (position of CRT beam when the Function Element Select operation was initiated), and
2. the vertical deflection to increment the CRT beam position by one vertical element.

To process the next horizontal raster line, the Function Element Select operation will have to be reinitiated.

The F1 function word format is illustrated in Figure 3-11. The Exposure Code 1 field will normally be interpreted first, followed by the Exposure Code 2 field, unless the RFO (Reverse Field Order) bit in the Initial Condition Select operation word (Bit 10) was set to a logical "1", which causes the Exposure Code 2 field to be interpreted first.

Bits 0 and 8 are the least significant bits of Exposure Codes 1 and 2, respectively. In 6-bit mode (Bit 1 set in the Initial Condition Select operation word), Bits 6, 7, 14, and 15 are ignored.



* Ignored in 6-bit mode.

Figure 3-11. F1 Word Format

3.4.2.3 F2, Adjacent Element

The F2 function (function code, 010 binary) specifies the adjacent plotting position of four consecutive elements. Each 16-bit input word is interpreted as four elements, decrementing the element count in Word 2 of the Function Element Select operation by four. When the number of elements equals the Element Count field, the operation is completed. The next input word from the computer will then be interpreted as an operation formatted word.

The Move fields (refer to Figure 3-12) contain a code that selects one of eight general directions that the CRT (cathode ray tube) beam can be moved for positioning each consecutive element (see note below). The codes and directions are listed in Table 3-11.

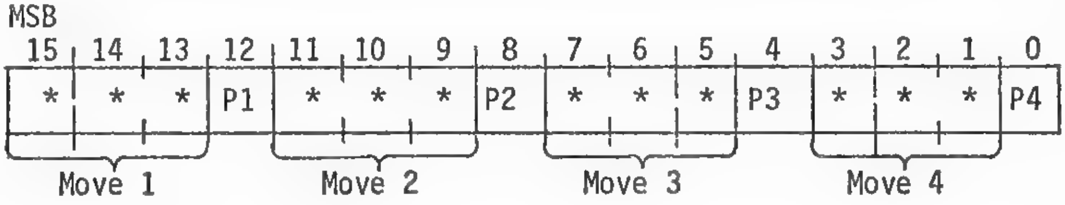
> _NOTE:_ *The element is plotted at the current CRT beam position, and then the beam is repositioned in the specified direction for plotting the next element.*

The P fields (P1-P4) determine the exposure level source for each plotted element as follows:

P field = logical "0": An element is plotted at the zero exposure level or at the background exposure level if the ABE field (Bit 8) of the Initial Condition Select operation word is a logical "1".

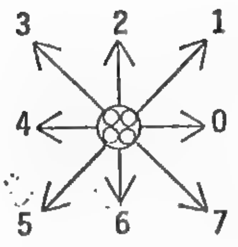
P field = logical "1": An element is plotted at the current exposure level specified by the Exposure Code field in Word 1 of the Function Select operation.

Normally the Move 1, P1 fields are interpreted first, followed sequentially by the Move 2, P2; Move 3, P3; Move 4, P4; Move 1, P1 of the next input word, etc. If the RFO (Reverse Field Order) bit in the Initial Condition Select operation word (Bit 10) is set to a logical "1", the fields are interpreted in reverse order, starting with Move 4, P4.



*Selected from Table 3-11.

Figure 3-12. F2 Word Format



Move
Directions

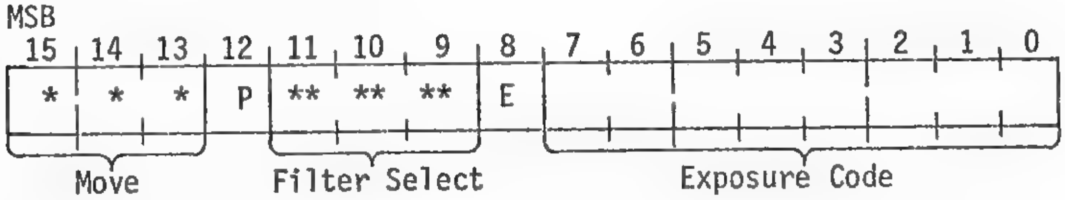
CODES (BINARY)	DIRECTION (SEE FIGURE AT LEFT)
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

Table 3-11. Move Direction Codes

3.4.2.4 F3, Single Element

The F3 function (function code, 011 binary) specifies the adjacent position, the exposure level source, the color filter, the next word format, and the exposure code for plotting each element. Each 16-bit input word is interpreted as one element decrementing the element count in Word 2 of the Function Element Select operation by one. When the number of elements equals the Element Count field, the operation is completed. The next input word from the computer will then be interpreted as an operation formatted word.

The F3 function word format is illustrated in Figure 3-13.



*See Table 3-11.
**See Table 3-9.

Figure 3-13. F3 Word Format

The fields are interpreted as follows:

Exposure Code field: (Bits 0 through 7)	Selects one of 256 (decimal) exposure codes representing exposure levels in 8-bit mode. In 6-bit mode, Bits 6 and 7 are ignored, limiting the selection to one of 64 (decimal) levels. Bit 0 is the least significant bit (LSB) for both modes.

E (Escape) field: (Bit 8)	When a logical "0", continues to interpret input words in the F3 word format. When a logical "1", the following input words from the computer will be interpreted in the F5 Pattern Element word format (refer to Paragraph 3.4.2.6). Each 16-bit input word will represent 16 elements. The Move, Filter Select, and Exposure Code fields of the last word interpreted in the F3 word format will be honored, and the P field will be ignored. It should be noted that the F3 input word, with the E field bit equal to a logical "1", is not counted as an element that decrements the Element Count field in the Function Element Select operation. The input words continue to be interpreted in the F5 word format until the number of elements processed equals the Element Count field.
Filter Select field: (Bits 9 through 11)	Selects one of the color filters according to the 3-bit code listed in Table 3-9.
P (Plot) field: (Bit 12)	When a logical "0", the element is plotted using the zero exposure code or the background exposure code if the ABE field (Bit 8) of the Initial Condition Select operation word is a logical "1". When a logical "1", the element is plotted at the exposure specified in the Exposure Code field (lower eight bits).
Move field: (Bits 13, 14, and 15)	Selects the direction that the CRT beam can be moved for positioning each consecutive element. The codes are listed in Table 3-11. NOTE: *The element is plotted at the current CRT beam position, and then the beam is repositioned in the specified direction for plotting the next element.*

3.4.2.5 F4, Short Vector or Position

The F4 function (function code, 100 binary) specifies the position and length, relative to the current CRT (cathode ray tube) beam position of a short vector or of a new beam position. Each input word permits the selection of:

1. The new horizontal and vertical CRT beam coordinate position values which are relative to the current beam position. A delta value of "1" corresponds to 1 part out of 4,096 of the total plotting area.

2. The adding or subtracting of the values in Step 1 to the current CRT beam position coordinates.

3. The plotting of a vector line.

Each 16-bit input word is interpreted as one element, decrementing the element count in Word 2 of the Function Element Select operation by one. When the number of elements (short vectors) equals the Element Count field, the operation is completed. The next input word from the computer will then be interpreted as an operation formatted word.

The F4 function word format is illustrated in Figure 3-14.

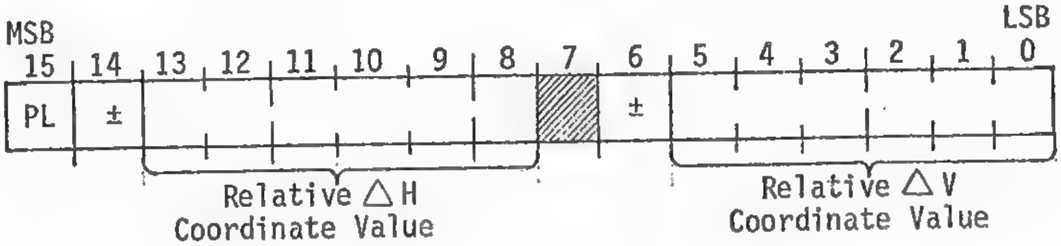


Figure 3-14. F4 Word Format

The fields are interpreted as follows:

Relative △V Coordinate Value field: (Bits 0 through 5)	Specifies the position value that may be added or subtracted to the current vertical CRT beam coordinate for plotting a vector and/or positioning the beam.
Relative △H Coordinate Value field: (Bits 8 through 13)	Specifies the position value that may be added or subtracted to the current horizontal CRT beam coordinate to arrive at a horizontal destination coordinate for plotting a vector and/or positioning the beam.
± field: (Bits 6 and 14)	When a logical "0", adds the position values to the current vertical and horizontal beam position coordinates, respectively. When a logical "1", subtracts the position values to the current vertical and horizontal beam position coordinates, respectively.

PL (Plot Line) field: (Bits 15)	When a logical "0", positions the CRT beam to the resultant destination position specified by the Relative △H and △V Coordinate Value fields (without plotting a vector line). When a logical "1", plots a vector line from the current CRT beam position to the resultant destination position specified by the Coordinate Value fields.

3.4.2.6 F5, Pattern Element

The F5 function (function code, 101 binary) specifies the bi-level exposure pattern for a string of sequential elements plotted in one direction. Each 16-bit input word is interpreted as 16 elements decrementing the element count, in Word 2 of the Function Element Select operation, by 16. When the number of elements equals the Element Count field, the operation is completed. The next input word from the computer is then interpreted as an operation formatted word.

The F5 function word format is illustrated in Figure 3-15.

MSB 15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	LSB 0
P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16

Figure 3-15. F5 Word Format

The P1 through P16 fields determine the exposure level source for each plotted element as follows:

P field = logical "0":	An element is plotted at the zero exposure level or at the background exposure level if the ABE field (Bit 8) of the Initial Condition Select operation word is a logical "1".
P field = logical "1":	An element is plotted at the current exposure level specified by the last Exposure Code field.

The D48 will start interpreting input words in the function F5 Pattern Element format following:

1. the execution of the Function Element Select operation code (001 binary) specifying the F5 function code (101 binary) in Bits 13, 14, and 15 of Word 2, or

2. the execution of the Function Element Select operation code specifying the F3 function code (011 binary) and setting the E field (Bit 8) to a logical "1" in any one of the following F3 formatted input words.

Normally the pattern bits are interpreted in the order starting with P1 and continuing sequentially with P2, P3, P4, etc. If the RFO (Reverse Field Order) bit in the Initial Condition Select word (Bit 10) is set to a logical "1", the fields are reversed with the order starting with P16 and continuing sequentially with P15, P14, P13, etc.

3.4.2.7 F6, Load Translation Table

The F6 function (function code, 110 binary) specifies two exposure codes for the exposure translation table. Each 16-bit input word is interpreted as two elements, decrementing the element count in Word 2 of the Function Element Select operation by two.

The F6 function word format is illustrated in Figure 3-16. The Exposure Code 1 field will normally be interpreted first, followed by the Exposure Code 2 field, unless the RFO (Reverse Field Order) bit in the Initial Condition Select operation word (Bit 10) was set to a logical "1", which causes the Exposure Code 2 field to be interpreted first.

The first 256 exposure codes received will be loaded into Translation Table No. 1. The second 256 exposure codes received will be loaded into Translation Table No. 2. The third 256 exposure codes received will be loaded into Translation Table No. 3. Additional exposure codes received will be ignored. Note that all three translation tables must be loaded with one function Element Select (FES) operation.

The translation tables are selected and deselected per encoded commands. See Section 3.4.1.1 and Table 3-3.

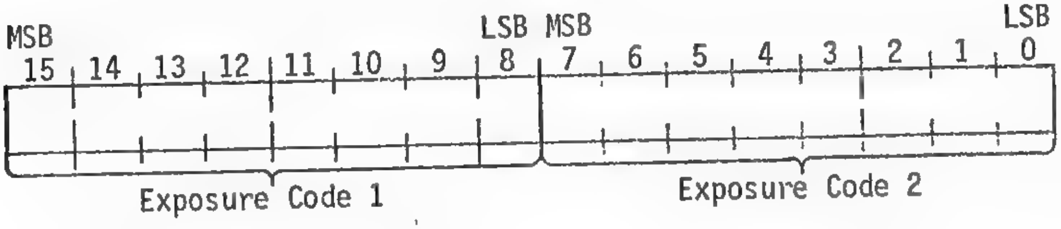


Figure 3-16. F6 Word Format

3.5 PROGRAMMING AND OPERATING GUIDELINES

Described in the following paragraphs are general guidelines for programming and operating the D48.

3.5.1 Programming Sequence

The recommended sequence for transmitting formatted input words from the computer differs according to the type of image being plotted. The two general classifications of images are vector and raster. Point plotting is included with vector images. A simplified sequence of instructions for programming each classification is listed on the following pages.

RASTER IMAGES

1. Reset the D48 by executing the Initial Condition Select (ICS) operation with the Reset bit (12) set to a logical "1".
2. Request the output status word from the D48 by executing the Encoded Command Select (ECS) operation and specify the Transfer Status Word command code (006_8). If the status word indicates that a problem exists, correct it before proceeding.
3. Select the desired operating features (refer to Table 3-8) by executing the ICS operation with the proper bits selected. The Reset bit (12) must be a logical "0".
4. Select the element size and spacing by executing the Point Element Select (PES) operation and specify the values for:

   ...the number of points per element,
   ...the spacing within the element, and
   ...the spacing between each element.
5. Position the CRT beam to the desired position by executing the Vector Position Relative or Absolute (VPR or VPA) operation and specify the required coordinate values.
6. Select the remaining plotting parameters (described in Paragraph 3.4.1.2) by executing the Function Element Select (FES) operation. The FES operation automatically starts the plotting process.
7. When the image is completed, check the output status for errors by repeating Step 2.

VECTOR IMAGES OR POINT PLOTTING

1. Repeat Steps 1 through 3 under raster images.
2. Position the CRT beam to the desired vector starting position by executing the Vector Position Relative or Absolute (VPR or VPA) operation and specify the required coordinate values.
3. Select the exposure level, filter, and film advance (if required) by executing the Exposure and Filter Select (EFS) operation.

4. Select the type of position coordinate values required (absolute or relative in respect to the current CRT beam position) by executing the VPR or VPA operation. It should be noted that the VPR and VPA operations provide for a Point or Position Designator (PPD) code (refer to Tables 3-6 and 3-7) which selects the point plotting, beam positioning, or vector plotting mode.

5. Repeat Steps 2 through 4 until the image is completed.

6. When the image is completed, check the output status for errors by executing the ECS operation and specify the Transfer Status Word command code.

Additional information to be considered when programming the D48 is listed below:

- EXPOSURE CONTROL FLOWCHART

  Figure 3-17 illustrates a programming flowchart for selecting the various exposure features in the D48.

- TIME SAVERS

  1. When plotting a multicolor image, it is recommended that all elements of one color be completed before starting the next color. A Filter Select command requires 333 milliseconds to execute.

  2. When selecting a filter and advancing film at the same time, execute the FES or EFS operation (whichever is applicable). With these two operations, the execution times for a filter select and a film advance are overlapped. With the ECS operation, the execution times are separate.

3.5.2 Positioning Images within the Camera Aperture

Several factors should be considered when positioning an image on film.

1. The CRT (cathode ray tube) beam plotting area.
2. The film plotting area.
3. The film size.
4. The camera aperture size.
5. The projector aperture size.

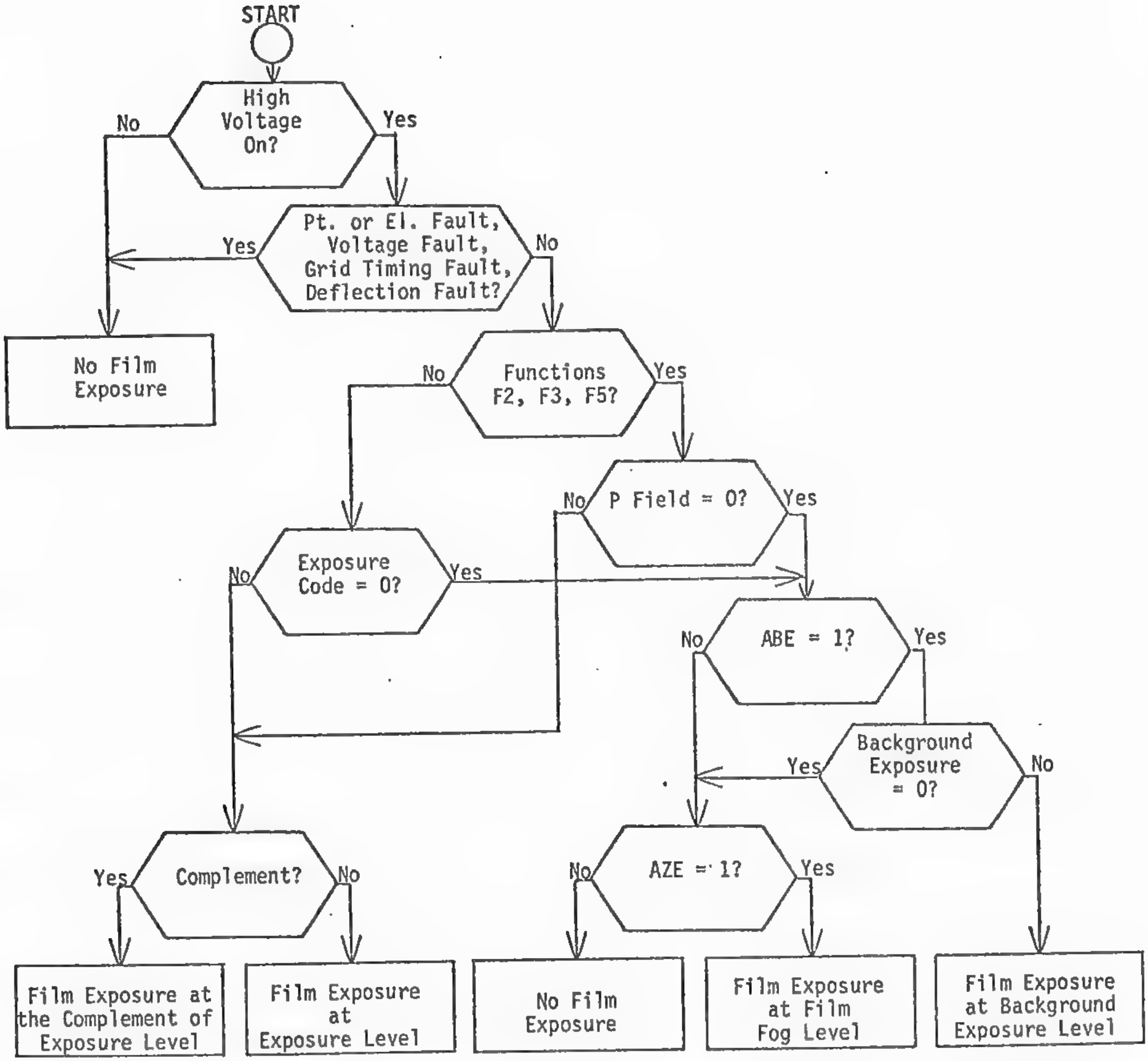

START
High Voltage On?
No
Yes
Pt. or El. Fault, Voltage Fault, Grid Timing Fault, Deflection Fault?
Yes
No
No Film Exposure
Functions F2, F3, F5?
No
Yes
P Field = 0?
No
Yes
Exposure Code = 0?
No
Yes
ABE = 1?
No
Yes
Background Exposure = 0?
Yes
No
Complement?
Yes
No
AZE = 1?
No
Yes
Film Exposure at the Complement of Exposure Level
Film Exposure at Exposure Level
No Film Exposure
Film Exposure at Film Fog Level
Film Exposure at Background Exposure Level

Figure 3-17. Exposure Control Flowchart

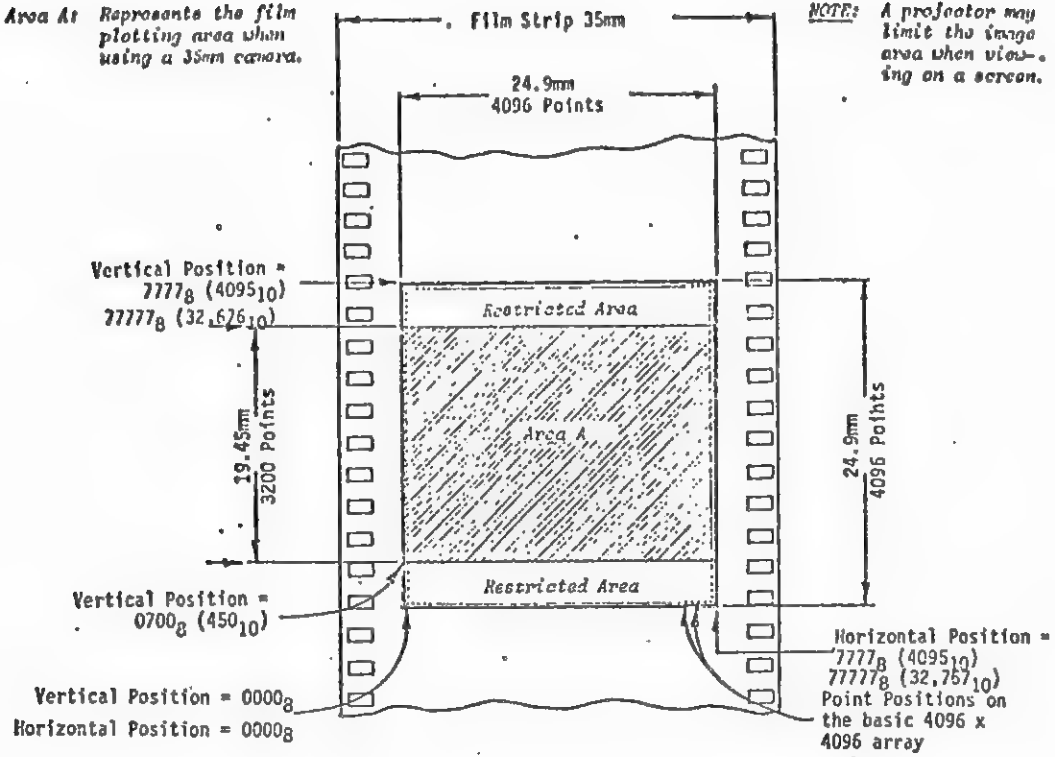

Area A: Represents the film plotting area when using a 35mm camera.
Film Strip 35mm
NOTE: A projector may limit the image area when viewing on a screen.
24.9mm
4096 Points
Vertical Position = 7777_8 (4095_{10})
77777_8 ($32,626_{10}$)
Restricted Area
Area A
19.45mm
3200 Points
24.9mm
4096 Points
Restricted Area
Vertical Position = 0700_8 (450_{10})
Vertical Position = 0000_8
Horizontal Position = 0000_8
Horizontal Position = 7777_8 (4095_{10})
77777_8 ($32,767_{10}$)
Point Positions on the basic 4096 x 4096 array

Figure 3-18. 35mm Film Plotting Area

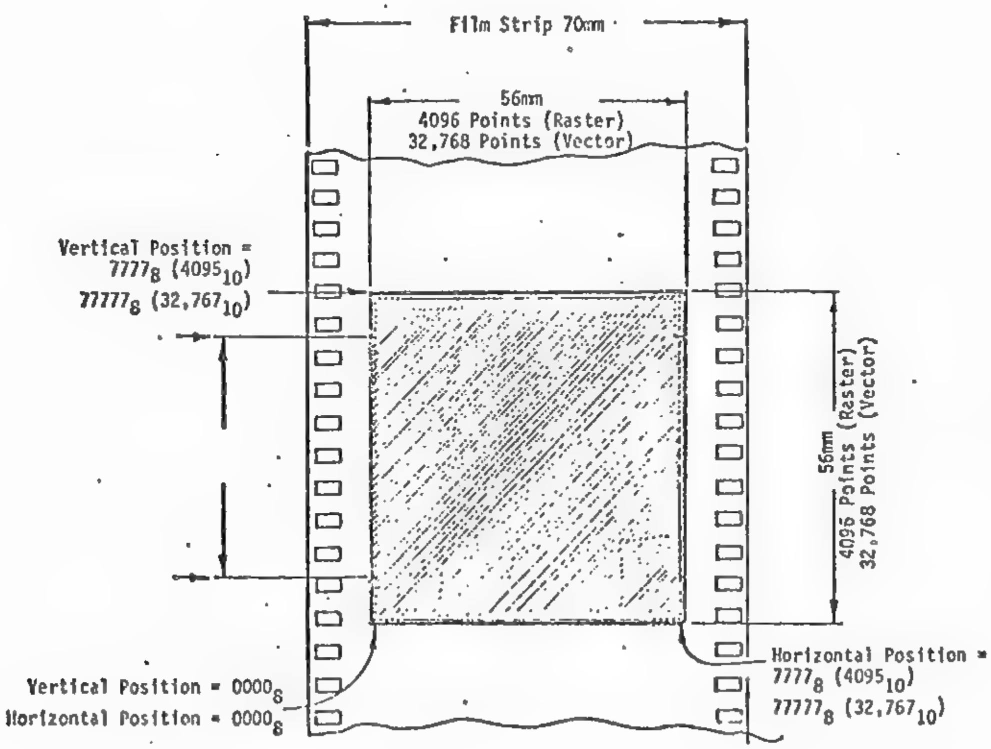


Figure 3-19. 70mm Film Plotting Area

Figure 3-18 illustrates the plotting area relative to 35mm film, and Figure 3-19 illustrates the plotting area relative to 70mm film. The dimensions are recorded in millimeters and in the number of plotting point positions relative to the basic 4096 x 4096 array in raster mode or 32,768 x 32,768 in vector mode.

The image area on 35mm film is approximately 24.9mm wide (horizontal dimension) and 19.45mm high (vertical dimension) which represents an array of 4096 points by 3200 points, respectively. The CRT beam must be positioned vertically, approximately 450 point positions in from the plotting area border, to avoid the restricted area caused by the camera aperture size.

The image area on 70mm film is approximately 56mm wide and 56mm high which represents an image array of 4096 x 4096 points in raster mode or a matrix of 32,768 x 32,768 points in vector mode.

To position the CRT beam within the camera aperture requires using one of the vector or position operation codes (010 or 011 binary). The beam positioning operation must be completed before executing an element processing operation.

3.5.3 Image Plotting Times

The total time required to plot an image is dependent upon:

1. The number of elements processed.
2. The number of points that make up each element.
3. The exposure level of each element.
4. The I/O interface.
5. The execution of related parameter selections, such as selecting filters, advancing film, positioning the CRT beam, etc.

Some of the applicable times are listed below:

● Element Processing Time:	The total time for processing each element is determined by multiplying the number of points within the element by the point processing time. The point processing time is variable, depending on the exposure level. The minimum processing time for a point is 4 microseconds, and the maximum processing time is 9 microseconds.
● Random CRT Beam Positioning Time:	The time required to reposition the CRT beam from the end of one horizontal line (element count depleted) to the beginning of the next horizontal line is 100 microseconds.

- CRT Beam Flyback Time: The time required to reposition the CRT beam from the end of one horizontal line (element count depleted) to the beginning of the next horizontal line is 100 microseconds.

  With the short end of line delay selected (Bit 9 of the Initial Condition Select operation), the flyback time is reduced to approximately 20 microseconds.

- Vector Generation Time: The time required to generate a vector line is determined by multiplying the △H or △V position value (whichever is greater), by 9 microseconds. The position values are the same as those used in the Vector Position Absolute or Relative operation word formats (refer to Paragraphs 3.4.1.3 or or 3.4.1.4, respectively).

- Film Advance Time: The time required to advance the precision roll film one frame is 667 milliseconds.

- Filter Selection Time: The time required to select any color filter is 333 milliseconds.

3.5.4 Control and Indicator Application

- REQUEST Switch/Indicator: The REQUEST switch (refer to Paragraph 1.3.8.1) provides an operator with the means of interfacing with a computer from the D48 control panel. A typical application may include loading and running the system software, which would illuminate the REQUEST indicator when the computer is ready to communicate with the D48. When an operator has loaded the film (refer to Paragraph 2.2.6), installed the film magazine (refer to Paragraph 2.2.7), and calibrated the exposure (refer to Paragraph 2.2.3), the REQUEST switch can be depressed, notifying the computer via the output status word that the D48 is ready to receive plotting information. The REQUEST switch will be ignored if the indicator is not illuminated.

- ATTN (Attention) Indicator: The ATTN indicator (refer to Paragraph 1.3.8.1) is controlled (turned off or on) from the computer. It may be used to get the attention of an operator for one of the following reasons:

1. A potential problem has been detected in the D48.
2. The system operation requires manual intervention.
3. A particular job is completed.

3.5.5 D48 Operating State

The following paragraphs describe the operating state of the D48 following various operating modes.

- Reset: The operating state of the D48 following a Reset action (programmed or manual) is described in Paragraphs 1.3.8.2 and 3.4.1.5. In addition to those items listed in the referenced paragraphs, a reset also causes:
    1. the ICS bits (selected with the Initial Condition Select Operation) to reset to the logical "0" state (refer to Paragraph 3.4.1.5),
    2. the Area Exposure to be selected (refer to Paragraph 3.5.7),
    3. the Color Exposure to be selected (refer to Paragraph 3.5.7),
    4. the exposure translation tables will be deselected, and
    5. the REQUEST indicator to extinguish (if illuminated), disabling the REQUEST switch.
- Test or Prime Mode: The operating state of the D48 following the test pattern generation or the prime mode is the same as that following a Reset action, with the exception that the V (vertical) Arithmetic Fault status bit gets set (refer to Paragraph 3.3).
- Calibration: The operating state of the D48 following the exposure calibration procedure is the same as that following a Reset action, with the following exceptions:
    1. The red filter is selected.
    2. The HV (high voltage) Disable status bit is set.

3.5.6 Transfer Output Status

The output status word is normally requested by the computer at the start of each plotted image. If the status bits indicate that a problem exists, do NOT proceed until corrective action is taken. Table 3-12 describes the function of each status bit. It should be noted that the state of each bit is unknown when applying power to the unit. Therefore, it is recommended that a Reset action (manual or programmed) be initiated after applying power and before transferring the status word to the computer. The following table summarizes the type of action required for each status bit.

STATUS BITS	CORRECTIVE ACTION
0, 1, 5, 6, and 10	Any one of these bits set normally requires immediate attention by maintenance personnel before proceeding. Do NOT attempt to plot information until the problem is corrected.
2 and 3	These bits set when the control panel disable switches, MAGAZINE DISABLE and FILTER DISABLE, are depressed, disabling the filter select or film advance operations. These bits may be ignored, depending upon the operation to be performed.
4	This bit sets when the high voltage power supply is off. The high voltage may be off due to the HV DISABLE switch on the operator panel, the HIGH VOLTAGE switch on the power panel, the D48 being in the calibrate mode, or due to an abnormal condition. Check for the high voltage missing in the following order: 1. The HIGH VOLTAGE switch on the power panel (refer to Figure 2-1). 2. The D48 not in calibrate mode (the CALIBRATE indicator extinguished). 3. The HV DISABLE switch on the operator panel (refer to Figure 1-10). 4. An abnormal condition. With an abnormal condition, do NOT attempt to plot information until the problem is corrected.
8, 9, and 10	These bits are normally set by programming errors due to: 1. incorrect point or element parameters (refer to Table 3-1), or 2. overflowing CRT beam position counters.
11	This bit monitors the P field in the input words from the computer and is normally only used for diagnostic purposes.
12	This bit is set by the REQUEST switch.
13	When this bit sets, the film magazine has run out of film, requiring an operator to reload the film magazine.
14 and 15	Not used.

Table 3-12. Status Summary

3.5.7 Additional Plotting Information and Reminders

- Plotting Sequence: The D48 always plots information at the current CRT beam position, and then the beam is repositioned in the specified direction for plotting the next element.

- Vectors: When plotting vector lines, the last position point determined by either the absolute or relative vector coordinates is NOT plotted.

  A vector operation specifying a zero length vector line is interpreted as a No Operation.

- Element Count: A zero value in the Element Count field of the Function Element Select operation (refer to Paragraph 3.4.1.2) is interpreted as 4096 elements to be processed.

- Points per Element: A zero value in the Horizontal or Vertical Points per Element fields of the Point Element Select operation (refer to Paragraph 3.4.1.6) is interpreted as 16 points in the respective direction for each element.

- Flyback Disable: The Flyback Disable feature (refer to Table 3-8) prevents the CRT beam from flying back to the original horizontal position when the element count has terminated. This feature is only used with the Function Element Select (FES) operation when the function codes F2, F3, and F5 are specified (plotting non-raster type line images).

  With the Flyback Disable not selected (bit reset to a logical "0"), the beam flies back to the original horizontal position (beam position at the start of executing the FES operation). This is the normal mode for plotting raster type images.

  NOTE: *With the flyback disabled, the program must be prepared to handle horizontal (H) or vertical (V) overflow conditions. An overflow will result if a point is plotted at the last position of the image area and the next point specified is in the direction of the edge (determined by the direction of the "Move" field; refer to Table 3-11).*

- Color or Black and White Exposure: The exposure on the D48 is adjusted for a black and white film and for a color film. The program must specify by using a command code as to which film is being used (refer to Table 3-3). The D48 in the reset state automatically selects the color exposure.

- Area or Line Exposure: The exposure on the D48 can be changed under program control so that a single point or line appears to have the same amount of exposure on film as several points or elements grouped together in an area. Generally several elements plotted in an area produce a more exposed image than single elements or lines produce. The D48 in the reset state automatically selects the area exposure.

- Exposure Translation: When the exposure translation tables are selected by use of the encoded commands specified in Section 3.4.1.1, the following will be true.

    1. All codes including the Background Exposure code will be translated.

    2. The Allow Zero Exposure (AZE) bit applies to the translated code.

3.5.8 Summary of Codes and Input Word Formats

Table 3-13 lists all of the codes that apply to the D48, and Figure 3-20 illustrates the simplified input word formats. The detailed input word formats for using the codes are illustrated in Figure 3-2.

OPERATION CODES

Codes (Octal)	Title
0	Encoded Command Select (ECS)
1	Function Element Select (FES)
2	Vector or Position Absolute (VPA)
3	Vector or Position Relative (VPR)
4	Initial Condition Select (ICS)
5	Point Element Select (PES)
6	Exposure and Filter Select (EFS)

FUNCTION CODES

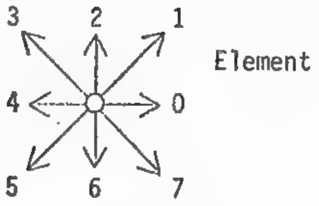
Codes (Octal)	Title
0	No Operation
1	Raster
2	Adjacent Element
3	Single Element
4	Short Vector or Position
5	Pattern Element
6	Load Translation Table

COMMAND CODES

Codes (Octal)	Title
0	No Operation
1	Illuminate ATTN Indicator
2	Extinguish ATTN Indicator
3	Illuminate REQUEST Indicator
4	Initiate Prime Mode
5	Initiate Test Mode
6	Transfer Status Word
7	Advance Film
10	Filter Unchanged
11	Select Red Filter
12	Select Green Filter
13	Select Yellow Filter
14	Select Blue Filter
15	Select Magenta Filter
16	Select Cyan Filter
17	Select Neutral Filter
20	Area Exposure
21	Line Exposure
22	Color Exposure
23	Black and White Exposure
24	Bypass Translation
25	B/W Translation
26	Color Translation

FILTER SELECT CODES

Codes (Octal)	Selected Filter
0	No Change
1	Red
2	Green
3	Yellow
4	Blue
5	Magenta
6	Cyan
7	Neutral



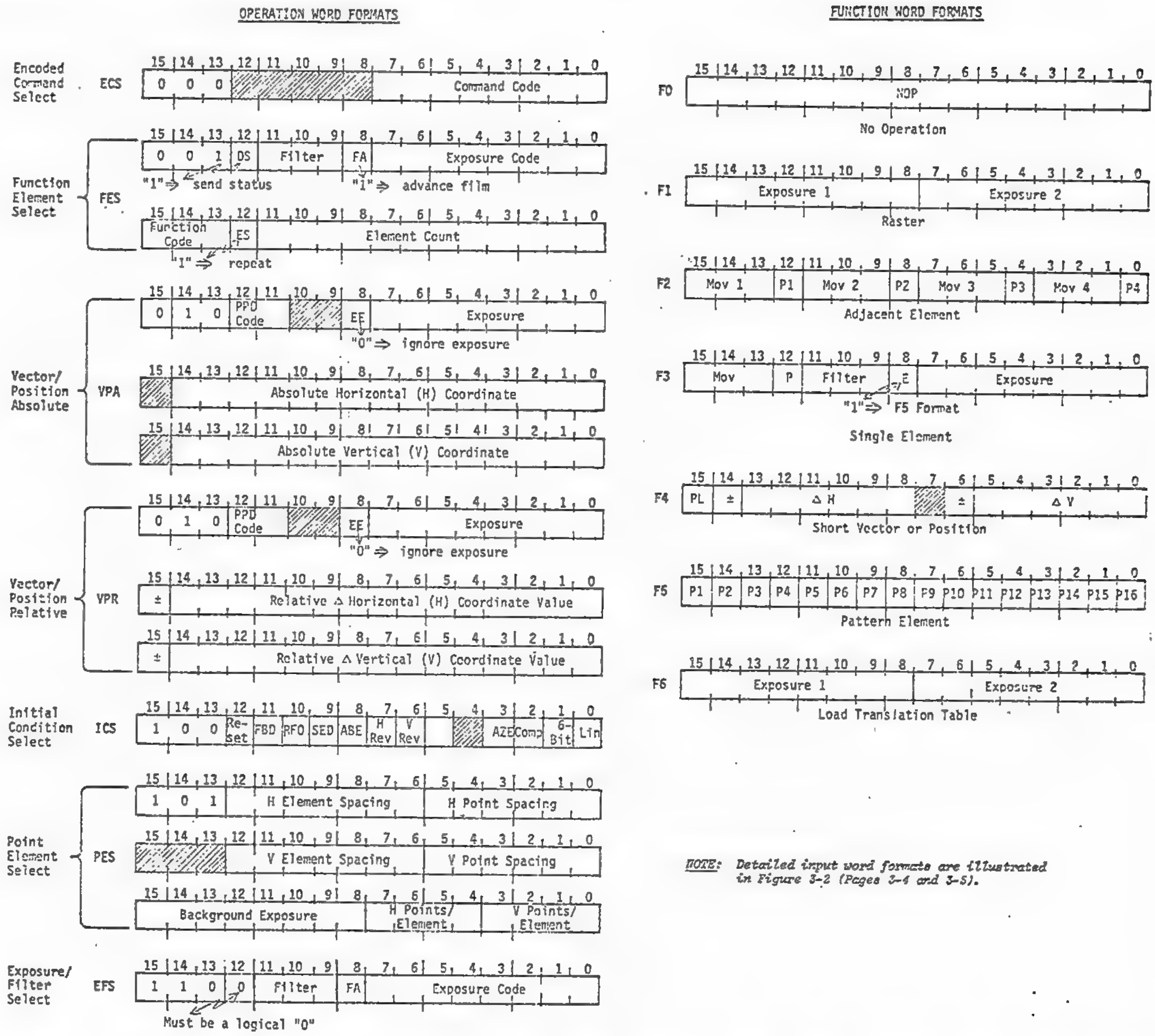
PLOT OR POSITION DESIGNATOR (PPD) CODES

Codes (Octal)	Title
0	Position CRT Beam
1	Position CRT Beam and Plot Point
2	Plot Vector Line
3	Not Used

MOVE CODES

Codes (Octal)	Direction (See Above)
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7

Table 3-13. D48 Codes



NOTE: Detailed input word formats are illustrated in Figure 3-2 (Pages 3-4 and 3-5).

Figure 3-20. Simplified Input Word Formats

Appendix A

SAFETY SUMMARY

Caution should be exercised when dealing with the following items:

- Camera Magazine

  Place the FWD/REV/OFF switch in the OFF position when loading or unloading film in the camera (refer to Paragraph 2.2.7, Film Magazine Installation Procedure, and Paragraph 2.2.10, 35mm to 16mm Camera Conversion Procedure).

- Film Threading

  When threading film in the transport, ensure that the film loops do not touch the case or restrict the film in movement or film damage will occur.

- Malfunctions

  Whenever equipment malfunctions occur, DICOMED Customer Service personnel should be notified immediately, and the D48 should NOT be operated further until the cause of the failure has been identified and corrected. Continued operation of the D48 while a malfunction exists could result in damaging the CRT (cathode ray tube).

Appendix B

INSTALLATION INSTRUCTIONS

- Visually inspect the D48 to make sure that it has not been physically damaged during shipment.

- Move the D48 to the desired operating position and level the cabinet by raising or lowering the adjustable feet.

- Contact a DICOMED Customer Service representative to make arrangements for him to visit your site to complete the installation check-out. Failure to contact a Customer Service representative before applying power to the D48 will void the equipment warranty unless authorization from DICOMED Corporation has been granted in writing.

APPENDIX C

DICOMED D48 SPECIFICATION SUMMARY

This specification defines the summary performance specifications for the DICOMED D48 Color Recorder.

1. Functional Performance

1.1 Recording Speed

The total time required to record an image on the D48 is dependent upon the number of points plotted, the exposure values and the execution of other related functions. Time requirements for certain of these functions are stated in Sections 1.1.1 through 1.1.7.

1.1.1 Input Data Word Interpretation

The maximum time required to interpret an input data word in preparation for the execution function specified in the word is three microseconds.

1.1.2 Adjacent Point Positioning

The maximum time required to advance the beam to the next adjacent point position is four microseconds.

1.1.3 Point Exposure Time

The maximum time required to expose any point is six microseconds. This exposure time, which corresponds to the length of dwell time at the position being exposed, is approximately proportional to the exposure level.

1.1.4 Random Position Time

The maximum time required to position the recording beam to any point on the plotting matrix is 100 microseconds.

1.1.5 Beam Flyback Time

The maximum time required to reposition the recording beam to the beginning of a new line in raster mode is 100 microseconds.

When in the SHORT END OF LINE DELAY (SED) mode, the beam positioning delay time is approximately 20 microseconds.

1.1.6 Vector Generation Time

The time required to generate a vector in the D48 increases in a nearly linear relationship with the vector length and the exposure level of the vector.

The maximum time to generate a full-screen vector at maximum intensity is 45 milliseconds.

1.1.7 Filter Position Time

The maximum time required to position any filter is 350 milliseconds.

1.2 Geometrics

The geometrics of the image at the film plane of the unit complies with the requirements stated in Sections 1.2.1 through 1.2.6. The spatial measurement parameters of the image array are defined in Figure 1.2-1.

1.2.1 Trapezoiding (T)

Trapezoiding is maintained within ±0.2 of the major axis and is defined as follows:

$$T_H(\%) = \frac{H_1 - H_2}{H_1 + H_2} \times 100$$

$$T_V(\%) = \frac{V_1 - V_2}{V_1 + V_2} \times 100$$

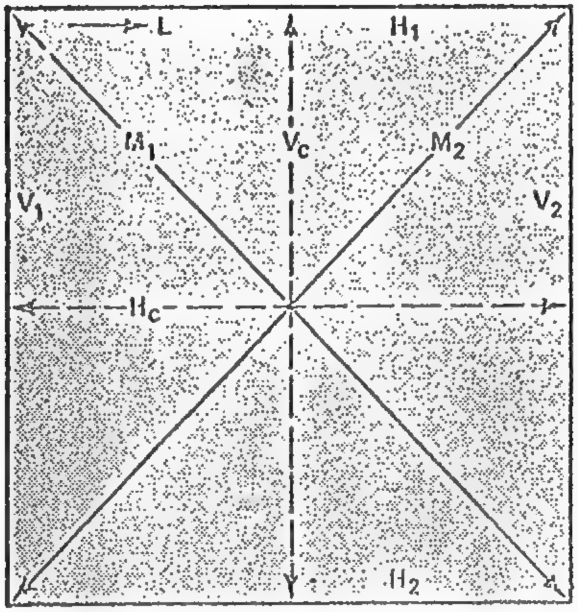
T_H and T_V are for the horizontal and vertical axes respectively.

1.2.2 Rectangularity (R)

Rectangularity (R) is maintained within ±0.2% of the major axis. Rectangularity, the deviation of the major axis lengths, is defined as follows:

$$R(\%) = \frac{H_c - V_c}{H_c + V_c} \times 100$$

H_c and V_c are the lengths of the major axis.



ARRAY GEOMETRICS

H_1 = Length of top horizontal line
H_c = Length of horizontal major axis
H_2 = Length of bottom horizontal line
V_1 = Length of left vertical line
V_c = Length of vertical major axis
V_2 = Length of right vertical line
M_1 = Length of matrix diagonal (0,0 to max., max.)
M_2 = Length of matrix diagonal (0, max. to max., 0)

1.2-1 Plotting Array
Measurement Parameters

1.2.3 Orthogonality (O)

The orthogonality of the horizontal and vertical axes is maintained within ±0.3%. Orthogonality is referenced to the major axis and expressed as a percentage of the matrix diagonal as follows:

$$O(\%) = \frac{M_1 - M_2}{M_1 + M_2} \times 100$$

1.2.4 Linearity (L)

Point spacing linearity is maintained within ±0.2% of the major axes. Linearity is evaluated for groups of points on the major axis by painting a test pattern on film which divides each of the major axes into eight segments. Point spacing linearity (L) is defined as follows:

$$L_H(\%) = \frac{S_H\text{max} - S_H\text{min}}{2H_c} \times 100$$

$$L_V(\%) = \frac{S_V\text{max} - S_V\text{min}}{2V_c} \times 100$$

S = length of segments along the major axis.

1.2.5 Line Curvature (P)

Pincushion distortion and/or line curvature is less than ±0.2% of the major axis. Pincushion distortion (P) is defined as the maximum deviation of any raster line from the best fit straight line and is expressed as follows:

$$P(\%) = \frac{d}{L} \times 100$$

d = deviation from best fit straight line.
L = length of the major axis (H_c or V_c).

1.2.6 Spatial Repeatability (S)

Stability of the deflection subsystem is measured in terms of spatial repeatability. This specification is defined as the deviation of any given point in time for subsequent scans. Spatial repeatability is maintained within ±0.05% of each major axis for successive images repeated during a 10-minute interval and ±0.10% of each major axis over a 30-minute interval after the unit has been allowed to warm up for one hour minimum.

$$S(\%) = \frac{d}{L} \times 100$$

Where d is the deviation of a point and L is the length of the major axis (H_c or V_c).

1.3 Photometrics

1.3.1 Exposure Range

The recorder provides a dynamic exposure range of two decades. Measurements made on the films specified in this document (and most commercially available films) yield the following results:

1.5D when processed to a gamma of 1.0
2.0D when processed to a gamma of 1.5

where D is measured in terms of diffuse density units, all other references to density (D) in this specification are based upon this definition.

1.3.2 Exposure Levels

The number of exposure levels in all modes is 256.

1.3.3 Exposure Uniformity

The uniformity of exposure over the entire plotting array is specified in diffuse density (D) assuming a film gamma of unity. The maximum uniformity deviation is ±0.15D measured through a circular aperture of 3 millimeters diameter.

1.3.4 Spatial Resolution

1.3.4.1 Film Plane Resolution

Spatial Resolution at the 35mm (24.9mm x 24.9mm image area) film plane is 40 line pairs/mm minimum. Resolution for other film formats are comparable. Resolution is defined as the number of visually resolvable line pairs over the image area. Resolution is measured on black and white film with an ASA rating of 160 or higher through the green filter.

This resolution is confirmed through the following process:

a. Line patterns are recorded on film in the vertical and horizontal directions. 1024 equally spaced lines are painted at maximum intensity. Adjacent lines are painted at zero intensity.

b. The film used for this test must have a daylight ASA speed of 160 and a limiting resolution of at least 200 line pairs per millimeter.

c. The film is processed to a gamma of 1.0 or greater, such that the maximum density of the line patterns are less than 1.8D.

d. The recording is performed with the green filter selected.

e. The test criteria is the visual resolution of the line pattern over the entire image area.

1.3.4.2 Resolution at the CRT Screen

Resolution at the CRT screen is 2048 line pairs minimum across the image area. This is demonstrated by microscope examination of vertical and horizontal lines drawn at the center and corners of the image area. The measurements are made under the following conditions:

a. Alternate lines are painted at maximum intensity with the adjacent lines painted at the zero intensity.

b. The pattern is painted in the raster mode on a matrix of 4096 x 4096 points.

c. The recorder is adjusted for a film speed of ASA 160 daylight or higher.

d. The test criteria is the visual resolution of 2048 line pairs.

2. Electrical Power

The unit operates on commercially available power without need of a special generator or converter unit.

2.1 Voltage, Frequency and Current

The unit operates on the following input power:

Input Voltage:	117 Volts A.C. ±10% single phase
Frequency:	50 to 60Hz
Current Steady State:	10 Amperes Maximum
Current Peak Inrush:	60 Amperes Maximum

2.2 Grounding

The equipment is provided with an electrical ground separate from the A.C. power line neutral. The line cord shall be terminated in three wire, U-ground, 15 ampere male connector, such as Hubbell No. 5266 or equivalent.

2.3 Power Line Transients

The system will operate as specified with powerline voltage fluctuations of up to one Volt/microsecond with an amplitude not to exceed 10 Volts.

2.4 Protection

The unit includes necessary protection to insure that momentary interruptions of the commercial power source, power line transients or line frequency fluctuations will not cause damage to internal components.

Internal D.C. power supplies are protected against over-voltage conditions.

3. Physical Requirements

3.1 Enclosure

The enclosure contains all the components, subassemblies and assemblies necessary for the operation of the unit. The enclosure provides for the connection of power and interface cables by means of separate electrical connectors. Panels, doors and rear skins are easily removable to permit access for maintenance and repair.

It is possible to gain access to any subassembly or assembly with the use of conventional hand tools. Materials used for the enclosure are such that no deformations, dents, fractures or breakage will occur through normal use and handling. The enclosure is capable of withstanding the specified environmental conditions without damage or deterioration.

3.2 Dimensions

The unit is 72 inches (183cm) high, 50.5 inches (129cm) wide and 23 inches (59cm) deep, including all protrusions of handles and connectors.

3.3 Weight

The unit weighs 500 pounds (228kg) maximum.

3.4 Painting and Finish

The unit is painted with DICOMED standard colors to provide pleasing appearance, and to provide protection to otherwise exposed metal parts.

3.5 Nameplate

The unit enclosure has a nameplate affixed to it in a permanent manner which states the manufacturer and equipment model number. Other identifying information, such as equipment name and serial number, is provided on the nameplate. The voltage, current and frequency of the primary power source from which the unit is designed to operate is included on the nameplate.

3.6 Electro-Magnetic Interference

The unit is designed to reduce susceptibility to both radiated and induced electro-magnetic interference. The cathode ray tube, together with associated yokes and coils, is enclosed in shielded enclosures within the cabinet enclosure.

3.7 Acoustical Noise

The unit is designed to operate without producing objectionable acoustical noise.

3.8 Cooling

The unit is designed to operate within the environment specified herein without being located in special air conditioned facilities.

3.9 Parts and Materials

The unit utilizes quality materials and parts which are expected to perform in accordance with vendor specifications over the operational life of the display unit.

3.10 Solid State Components

All active components are solid state, with the exception of the CRT and color wheel drive components. In addition, all relays (except the Power-On relay) are solid state.

3.11 Cathode Ray Tube

The CRT has a usable image area of 2.9 x 2.9 inches (7.4cm x 7.4cm) upon which images can be generated. The spot size is 20 microns or less at the 50% amplitude points at a cathode current of 1.0 microamperes when measured by the vendor using a two-slit analyzer.

3.12 Circuit Modules

All logic and discrete control circuitry (other than certain power or motor control components) are located on plug-in card modules.

3.13 Identification of Parts and Subassemblies

DICOMED part numbers and reference designations are exposed on each major component, subassembly and assembly, such that each major component, subassembly and assembly is easily identifiable by its part number or reference designations. Reference designations are used to identify and relate the location of lower level components and subassemblies to higher level subassemblies and assemblies. Reference designations conform as closely as practical to specification USAS Y32.16-1968, referenced in Section 2 of this specification.

3.14 Part Interchangeability

All components, subassemblies and assemblies with the same part number are physically, electrically and functionally interchangeable.

3.15 Human Factors

The unit has favorable characteristics with regard to human factors in respect to the overall appearance of the unit, the placement of controls, the style, lettering and color of indicators and the ease of operation and maintenance.

3.16 Safety Features

The unit is designed to conform with Underwriter's Laboratories (U.L.) standards for safety.

4. Environmental Requirements

The unit is capable of being operated within the environment specified herein.

4.1 Operating Temperature

The unit shall operate as specified over a range of room temperatures from 15° C to 35° C, and after having been stored indefinitely within a range of 0° C to 60° C.

4.2 Humidity

The unit shall operate as specified over a relative humidity range of 10 to 60 percent (non-condensing), and after having been stored indefinitely within a range of 5 to 90 percent.